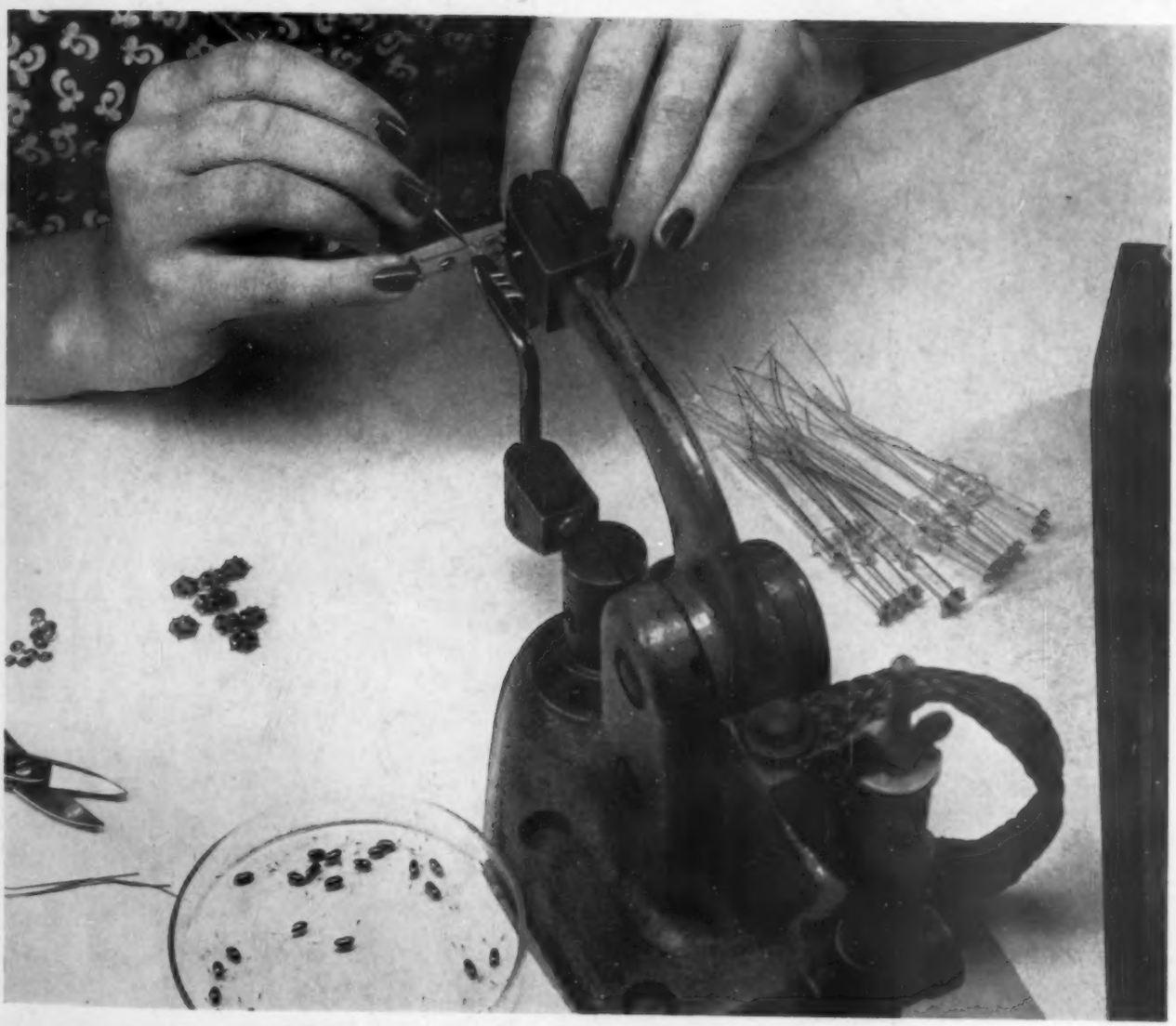
EAST ENGINEERING
LIBRARY

JUN 2 8 1946

JUNE 1946

The WELDING Journal



The Journal of the American Welding Society

ARCOS Monend for welding "MONEL"*

[BASE METAL CONTAINING APPROX. 65% Ni—28% Cu]

Arcos now offers Monend, the electrode for welding the much-used "Monel" metal. Monend is the right electrode for fabricating wrought, cast or clad "Monel".

Complete details and samples of Monend, or any other of the Arcos electrodes for welding nickel or nickel-copper alloys shown at the right, will be sent upon request.

When so much depends on so little . . . specify Arcos.

*Inco Trademark

ARCOS ELECTRODES FOR WELDING NICKEL AND NICKEL-COPPER ALLOYS

Nickelend — Nickel
Monend — "Monel"
Nicuend — Cupro-Nickel

ARCOS

ARCOS CORPORATION, 310 Gulf Bldg., Philadelphia 2, Pa.

Your Arcos Distributor is well informed. Your Arcos Distributor has Stock.

NEW ENGLAND

Hartford, Conn. — Arcos Corporation

MIDDLE ATLANTIC

Buffalo, N. Y. — Root, Neal & Co.
Erie, Penna. — Boyd Welding Co.
New York, N. Y. — Arcos Corp., Phila. 2, Penna.
New Jersey — Arcos Corp., Phila. 2, Penna.
Philadelphia, Pa. — Arcos Corporation
Pittsburgh, Pa. — Williams & Co., Inc.
Rochester, N. Y. — Welding Supply Co.
Syracuse, N. Y. — Welding Supply Co.

SOUTH and SOUTHWEST

Baton Rouge 17, La. — Louisiana Welding Co.
Borger, Texas — Hart Industrial Supply Co.
Houston, Texas — Champion Rivet Co. of Texas
Kingsport, Tenn. — Slip-Not Belting Corp.
Knoxville, Tenn. — Slip-Not Belting Corp.
Albuquerque, N. Mex. — Industrial Supply Co.
New Orleans, La. — The Gulf Welding Equipment Co.
Oklahoma City, Okla. — Hart Industrial Supply Co.
Pampa, Texas — Hart Industrial Supply Co.
Phoenix, Arizona — Arizona Welding Co.
Tucson, Arizona — Arizona Welding Co.
Tulsa, Oklahoma — Hart Industrial Supply Co.

MIDDLE WEST

Chicago, Ill. — Machinery & Welder Corp.
Cincinnati, Ohio — Williams & Co., Inc.
Cleveland, Ohio — Williams & Co., Inc.
Columbus, Ohio — Williams & Co., Inc.
Detroit, Michigan — C. E. Philips & Co., Inc.
Ft. Wayne, Ind. — Wayne Welding Sup. Co., Inc.
Indianapolis 2, Ind. — Sutton-Garten Co.
Kansas City, Mo. — Welders Supply & Repair Co.
Milwaukee, Wis. — Machinery & Welder Corp.
Moline, Ill. — Machinery & Welder Corp.
St. Louis, Mo. — Machinery & Welder Corp.
Wichita, Kansas — Watkins, Inc.

WEST COAST

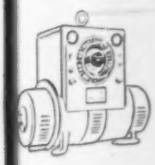
Bakersfield, Calif. — Victor Equipment Co.
Fresno, Calif. — Victor Equipment Co.
Los Angeles, Calif. — Victor Equipment Co.
Portland, Ore. — J. E. Haseltine & Co.
San Diego, Calif. — Victor Equipment Co.
San Francisco, Calif. — Victor Equipment Co.
Seattle, Wash. — J. E. Haseltine & Co.
Spokane, Wash. — J. E. Haseltine & Co.
Tacoma, Wash. — J. E. Haseltine & Co.

FOREIGN

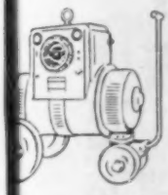
Honolulu, Hawaii — Hawaiian Gas Products, Ltd.
Monterrey, N. L. Mexico — Electrodos Monterrey, S. A.
Montreal, Canada — G. D. Peters & Co. of Canada, Ltd.
Chile, Bolivia, Peru — W. R. Grace Company

"HERE'S HOW to choose the right *HOBART* Simplified Arc Welder"

Each and every one of these arc welders will make your post-war welding production and maintenance jobs easier and more profitable.



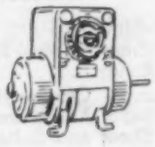
HOBART Electric Stationary
Where installation of the arc welder is to be permanent, the Electric Drive Stationary is recommended. Has all the exclusive Hobart features that get better welds faster. Ideal for factory production work.



HOBART Electric Portable
Most popular for average shop welding where electric power is available, and shop portability is required. In a selection of sizes and welding ranges, depending upon the type of work under repair or production.

HOBART Gas Engine Drive Stationary. For welding work where electric power is not available and portability isn't essential. This Stationary Gas Engine Welder is used extensively on long term construction jobs in the field.

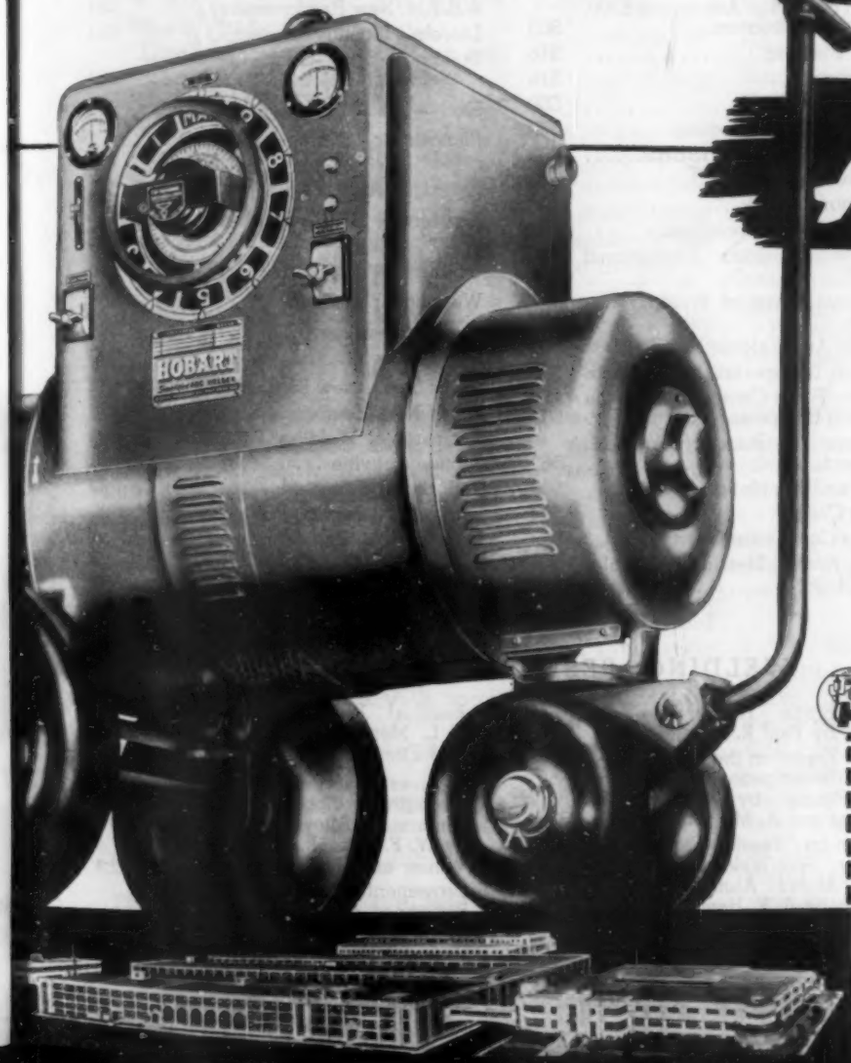
HOBART Gas Drive Trailer Type
A welder that can go anywhere! A "must" for all types of construction work such as bridge building, pipe line welding, building construction, shipbuilding and general maintenance.



HOBART "Build Your Own" Generator. You can "Build Your Own" gasoline driven arc welder by using the Hobart Generator with a good reconditioned auto engine and chassis. You can save hundreds of dollars over the cost of a complete factory-built unit.

HOBART Special Portable Types
Special welder shown is a self-powered arc welder designed for railway yard maintenance. If you have an application that requires specially designed equipment, we'll welcome inquiries.

HOBART A. C. Arc Welders
For shops that have only single phase 220 volt power available. Will do all types of light maintenance and production welding easily and quickly. Easily moved from one job to another.



HOBART

Simplified ARC WELDERS *. . . are More Profitable!*

How will Hobart Arc Welders make you more money? By making it easy to get the exact welding heat for perfect welds, by giving you more for your money in rated capacity, by lasting years longer through cooler operation . . . it's easy to weld faster and better. Use the coupon for complete details.

HOBART BROS. CO., BOX WJ-66, TROY, OHIO
"One of the World's Largest Builders of Arc Welders"

HOBART BROTHERS CO., Box WJ-66, Troy, Ohio

Send me the free book, also details on items I've checked—all without obligation.

- ☐ Electric Stationary
- ☐ Electric Portable
- ☐ Stationary Gas Drive
- ☐ Portable Gas Drive
- ☐ Generator Only
- ☐ A. C. Arc Welder
- ☐ Special Portable Types
- ☐ FREE Electrode Booklet

FREE!
"Welder's Vest Pocket Guide"

NAME _____

FIRM _____ POSITION _____

ADDRESS

The Journal of the American Welding Society

Published for the Advancement of the Science and Art of Welding

W. SPRARAGEN, Editor

JUNE, 1946

VOLUME 25 NUMBER 6

OFFICERS—1945–1946
President, W. F. HESS
First Vice-President, H. O. HILL
Second Vice-President, G. N. SIEGER
Treasurer, O. B. J. FRASER
Secretary and Asst. Treasurer, M. M. KELLY
Handbook Editor and Associate Secretary, H. O. KLINKE
Technical Secretary, L. M. DALCHER
Assistant Technical Secretary, SIMON A. GREENBERG

District Vice-Presidents
District #1 (New York & New England)—F. W. DAVIS
District #2 (Mid-Eastern)—W. G. THEISINGER
District #3 (Southern)—SYDNEY SWAN
District #4 (Central)—B. L. WISE
District #5 (Mid-Western)—R. E. McFARLAND
District #6 (Mid-Southern)—M. A. BARRETT
District #7 (Western)—C. P. SANDER

COVER

Welding Wire Mounts in the Manufacture of Thermistors. *Courtesy Western Electric Company.*

ISSUED MONTHLY

Copyright 1946, by
The American Welding Society

Subscriptions $5.00 per year in United States and possessions: Foreign Countries $7.00. Single copies, non-members $.75; Special issues October and December $1.00; members 50 cents

Entered as second-class matter January 15, 1932, at the post-office at Easton, Pa., under the act of March 3, 1879.

PUBLICATION OFFICE
20th & Northampton Streets, Easton, Pa.

EDITORIAL AND GENERAL OFFICES
33 West 39th St., New York 18, N. Y.

The Society is not responsible for any statement made or opinion expressed in its publications. Permission is given to reprint any article after its date of publication provided proper credit is given.

CONTENTS

TECHNICAL PAPERS, ITEMS AND REPORTS

Welding of 3½% Ni-0.40% Carbon Class An Steel Forgings, by Bela Ronay 495

Manual Oxyacetylene Flame Brazing of Aluminum, Aluminum Alloy Sheet and Subassemblies, by F. Clark 505

Soft-Soldering Nonferrous Metals, by G. H. Bohn 513

Fundamentals Affecting the Bond in Pressure Welds, by Leslie Fine, Charles H. Maak and Anthony R. Ozanich 517

"Shooting Star" Engine Is Triumph for Modern Welding, by J. G. Shaw, Jr. 529

Some Results of Advances in Welding and Radiography on the Welding of Pressure Vessels, by O. R. Carpenter 531

Current Welding Literature 542

Changeover of a Band Saw to Welded Design, by J. R. Morrill 543

Melting Points of Metals and Alloys, by H. R. Morrison 545

Procedures for Arc Welding Gray Iron Castings, by C. E. Phillips .. 547

Welding of Magnesium, by LeRoy F. Pearsall 549

SOCIETY AND RELATED ACTIVITIES

Lincoln Foundation Announces $200,000 Award Program 503

Annual Meeting 516

Metal Progress 516

1946–47 Nominations 550

Board of Directors Meeting 550

INDEX TO ADVERTISERS 552

Executive Staff of A.W.S. 556

Klinke Joins Society 556

Champion New Appointments 558

R. M. Wilson Joins International Nickel 558

Comparison Chart of Welding Materials 558

American Arc Welding Patents 560

Champion Transportation Sales, Inc. 560

The Valley Forge Caravan Salutes the Welding Equipment Industry 560

Supplement to Book of A.S.T.M. Standards 562

Heating and Ventilating Society 562

Building Codes 562

Electrode Correlation Chart 562

A.S.T.M. Annual Meeting in Buffalo, June 24–28 564

A.S.T.M. New Headquarters 564

Lincoln's Incentive System 564

Building Your Own Gas Drive Welder 564

Ogilvie Made District Manager 564

Photoelastic Stress Analysis Pamphlet 564

Hydrogen Aids Welding 564

New Movie, "This Is Resistance Welding" 566

Obituary 568

Welding Applications 568

Book on Radiology 568

New Products 570

Arcos Opens New England Offices .. 572

List of New Members 576

Abstracts of Welding Patents 580

Section Activities 580

R. S. Stover Promoted 590

Employment Service Bulletin 590

Division of Engineering, N.R.C. Appoints Louis Jordan 590

Sheffer Promoted 590

WELDING RESEARCH SUPPLEMENT

DeForest Brittle Temperature Research, by Paul R. Shepler 321-s

Summary Report on the Joint E.E.I.—A.E.I.C. Investigation of Graphitization of Piping, by S. L. Hoyt, R. D. Williams and A. M. Hall 332-s

Discussion on "Tension Tests of Single-Row Spot-Welded Joints in 24S-T Alclad Aluminum Alloy Steel," by A. R. Hard 339-s

A Method for the Measurement of Residual Welding Stresses, by J. L. Meriam, E. Paul DeGarmo and Finn Jonassen 340-s

An Investigation of the Fatigue Strength of Spot Welds in the Aluminum Alloy Alclad 24S-T, by W. F. Hess, R. A. Wyant, F. J. Winsor and H. C. Cook 344-s

Improvement of the Notch Impact Resistance of Gas-Welded Joints, by A. Matting and H. Koch 359-s

The Journal of
The American Welding Society
VOLUME 25 · NUMBER 6 · JUNE, 1946

Welding of 3½% Ni–0.40% Carbon Class An Steel Forgings*

By Bela Ronay†

FORESEEING the nature and type of warfare the approach of which appeared to be threatening late in 1941, the Bureau of Ships, Navy Department, directed the Naval Engineering Experiment Station in Annapolis, Md., to investigate the feasibility of repairing damaged propeller shafting by metal arc welding.

Propulsion shafting used in naval vessels is normally in the form of hollow forgings of steel conforming to the requirements for Class An of Bureau of Ships Specification 49S2 (INT). One composition which has been widely used for the manufacture of propulsion shafting and which is the composition forming the subject of this investigation is listed below. This steel is heat treated to meet the physical property requirements of the specification which are also listed herewith. Liquid quenching is not permitted.

Chemical Composition: C, 0.35–0.45; Mn, 0.6–0.9; S, 0.04; P, 0.045; Si, 0.15–0.25; Ni, 2.75–3.75.

Physical Properties:

Tensile strength = 80,000 psi. min.
Proof Stress = 45,000 psi. min.
Elongation in 2 in. = 25% longitudinally.
Elongation in 2 in. = 21% transversely.
Reduction of area = 45% min.
Cold bend around 1-in. diam. bar = 180°.

The task of welding an alloy of the above composition in a manner which renders the weldment suitable for use as ship's propeller shaft has been resolved into the following investigations:

(*a*) Evaluation of commercially available welding electrodes capable of yielding weld metal whose physical properties (both static and dynamic) are comparable to those of the base metal.

(*b*) Development of the applicable welding procedure with particular regards to the metallurgical changes which occur in portions of the base metal directly exposed to the thermo-cycle of welding.

(*c*) Development of the applicable technique to weld tubular shafting whose wall thickness ranges from 2 to 6 in.

(*d*) Development of apparatus and devices to rotate the weldment and to facilitate control of alignment and also to enable the performance of localized preheating and stress relieving.

(*e*) Design of the joint with special consideration for manual welding in grooves up to 6 in. in depth with the weldment rotating, and the method of assembling the joint.

(*f*) Development of the design and procedures for welding such defects as corrosion-fatigue cracks, worn keyways and the filling up of plug-holes.

The various phases of the above listed investigations are presented in the following:

Evaluation of the Applicable Welding Electrodes

In selecting welding electrodes for appraisal there were considerations other than those of the tensile properties of the weld metal deposited from them.

The weld metal applicable to weld normalized Class An steel shafting must possess the same endurance values in bending and in torsion as the base metal. Further, the weld metal must possess the above qualities subsequent to having been subjected to the stress-relief treatment. The latter must also suffice to restore the original physical properties of the heat-affected portions of the base metal.

In the event that the electrode design requires the use of a high current rate it may follow that the deposited metal becomes enriched in carbon and also in nickel. The so enriched metal is prone to develop cracking tendencies which would obviously prohibit the use of that electrode, regardless of the acceptable physical properties obtained for weld metal deposited in other than 0.35–0.45% C–3½% Ni steel assemblies. For obvious reasons the use of weld metal deposited from austenitic steel electrodes also had to be considered, although with misgivings, in that the presence of a nonmagnetic material in the weld did not augur well for the feasibility of accomplishing the stress-relief treatment by induction heating employing a 60-cycle power source.

Based on the foregoing the following types of electrodes were investigated.

Electrode Designation,	Approximate Analysis of the Deposit					
	C	Mn	Si	Cr	Ni	Mo
A	0.12	0.50	0.15	...	...	0.50
B	0.10	...	...	25.0	20.0	....
C	0.12	...	...	...	2.5	....
D	0.12	0.60	...	0.3	1.0	0.75

The above electrodes were deposited into butt joints formed by forged 1-in. thick Class An steel plates measuring 1 x 8 x 16-in. and which were of the following composition: C, 0.35; Mn, 0.62; Si, 0.24; S, 0.04; P, 0.01; Ni, 3.35%.

Welding was performed for all the above electrodes at various preheat and interpass temperatures ranging from 300 to 500° F. All weldments were stress relieved at 1175° F. for 2 hr. and were cooled with the furnace to room temperature. A sufficient number of weldments were produced to yield material for the fabrication of the following types of test specimens:

* Scheduled for Twenty-Sixth Annual Meeting, A.W.S., October 1945.
† Principal Welding Engineer, U. S. Naval Engrg. Experiment Sta., Annapolis, Md.

Table 1—Physical Test Results

ASSEMBLY NO.	ELEC-TRODE TYPE	PRE-HEAT °F	INTER-PASS TEMP °F	BENDS			TENSIONS						CHARPY IMPACT TENSION				NOTCHED CHARPY			HARDNESS SURVEY		
				TYPE OF BEND	ANGLE OF BEND	REMARKS	TYPE OF SPEC.	TENSILE STRENGTH P.S.I.	YIELD POINT P.S.I.	ELONG. %	RED. OF AREA	REMARKS	ENERGY ABSORBED FT. LB.	ELONG. IN 2" %	RED. OF AREA %	REMARKS	LOCATION OF NOTCH	ENERGY ABSORBED FT. LB.	REMARKS	ZONE OF SURVEY	ROCK-WELL "B"	BRINELL (CON-VERTED)
40X1	A	550-600	600	℄	180°	NO BLEMISH	TRANS. 0.505	88 400		(1) 38.0	67.4	CUP FRACTURE IN WM	64.02	17	69	FAILED THRU FZ	FZ	34.38	SOUND FRACTURE	BM	88	183
																				FZ	86	183
																	℄	41.65	SOUND FRACTURE	WM	73	156
40X2	A	450-500	450-480	FZ	90°	FAILED IN WM	•	88 400		(1) 24.0	36.3	IRREGULAR FRACTURE IN WM	27.03	9.5	17	FAILED THRU FZ	FZ	28.40	SLAG INCLUSION	BM	83	156
																	℄	42.30	SOUND FRACTURE	FZ	88	179
																				WM	75	167
40X3	A	350-400	315-360	FZ	120°	•	•	73 800		(1) 28.0	44.6	CUP LIKE FRACTURE IN WM	55.67	18	71	•	FZ	38.19	SLAG INCLUSION	BM	86	156
																	℄	36.67	SOUND FRACTURE	FZ	88	163
																				WM	88	163
40X4	A	480-500	440-480	FZ	180°	EDGE CRACK EXTENDING INTO THE FZ WITHIN THE WM	•	86 700		(1) 13.0	22	IRREGULAR FRAC. SHOWING SLAG INCLUSIONS	102.82	3	6	FAILED IN WM	FZ	42.48	•			
																	℄	38.67	•			
40X5	A	350-400	350-430	FZ	180°	SMALL CRACK IN WM	•	68 180		(1) 32.0	60	CUP FRACTURE IN WM	98.87	16	71	•	FZ	35.98	•			
																	℄	38.71	•			
40X6	B	350-450	370-388	℄	75°	FAILED IN FZ	•	88 100		(1) 80.0	17	FAILED THRU FZ	97.26	8.5	11	FAILED IN FZ	FZ	88.60	ONE WORMHOLE	BM	88	156
																	℄	33.91	SOUND FRACTURE	FZ	88	179
																				WM	86	163
40X9	B	380-480	368-378	FZ	180°	SMALL DEPOSIT IN FZ	•	88 400		(1) 50.0	61	CUP FRACTURE IN BM	45.90	3	3	•	FZ	33.91	•			
																	℄	40.34	•			
40X10	C	400-480	320-378	℄	90°	CRACK AT FZ	TRANS. RECTANGULAR CROSS SECTION	88 700				SOUND FRACTURE					FZ	23.20	•	BM	86	163
																	℄	21.92	ONE WORMHOLE	FZ	88	179
																				WM	79	167
40X15	C	•	•				ALL WM 0.505	78 750	43 800	(2) 15	24.9	IRREGULAR FRACTURE										
40X20	D	400-480	300-378	SIDE	180°	NO BLEMISH	TRANS. RECTANGULAR CROSS SECTION	86 000				WM FRACTURE										
				FACE ℄	60°	WM CRACK			(3)	(2)							℄	24.69	SOUND FRACTURE	BM	86	163
																				FZ	88	179
																				WM	90	183
40X23	D	•	•				ALL WM 0.505	98 500	86 500	20.5	54.4	CUP FRACTURE										
								88 500	80 000	22.0	56.7	•										
BASE METAL							0.505	92 920	80 000	24.0	49.2		151.83	18	47.6		BM	29.83				
									(3) 58 900				163.84	18	57.0		BM	27.13				
N.D SPEC 4952: (NOV. 1, 1938) CLASS An								80 000 (MIN)	45000 (MIN)	28.0 (MIN)	40.0 (MIN)											

NOTES

(1) – ELONG. IN 1"
(2) – ELONG. IN 2"
(3) – PROOF STRESS
℄ – CENTER LINE OF WELD.
FZ – FUSION ZONE
WM – WELD METAL
BM – BASE METAL

ENDURANCE LIMIT IN ALTERNATING TORSION OF WELD METAL (*P.S.I.*)

TYPE "A" ELECTRODE: 19,000 - 20,000
" "B" " 19,000 - 20,000
" "C" " 19,000 - 20,000
" "D" " 24,000 - 25,000

(*a*) All-weld metal tension, 0.505 in. diam.
(*b*) Side bend.
(*c*) Face bend.
(*d*) Impact, Charpy—keyhole notched.
(*e*) Tensile impact, 0.236 diam. 2 in. gage length.
(*f*) Torsion fatigue, 0.500% diam. (all-weld metal and composite, with weld at mid-length).
(*g*) Corrosion (salt water).
(*h*) Hardness, from transverse weld sections.
(*i*) Metallographic samples.
(*j*) Chemical samples.

The corrosion specimens, (*g*) above, were fabricated in the following manner:

Sections of 3-in. diameter, Class An, 3½% nickel steel shafting were machined to contain "U" bottom grooves of such depth that it permitted the deposition of three to four passes plus the usual seal beads. These weldments were stress relieved as given above for the plate assemblies, then machined to fit the arbor of a vertical rotator device used for corrosion testing. Each specimen containing a band of weld metal was immersed in a receptable through which Severn River water was passed at a regulated rate. (The salt concentration of Severn River Water is one-third that of Seawater.) The rotator was actuated for 22 consecutive days (24 hr. per day) at 1000 rpm.

The results of the tests performed for the specimens (*a*) through (*h*) given above, are shown in Table 1. The photographs, Figs. 1 and 2, show typical corrosion specimens as machined and subsequent to the 22-day exposure, respectively. The specimens represented by that shown on Fig. 2 contained weld metal produced from the Type D electrodes which deposit an alloy of approximate 0.30% Cr, 1.00% Ni and 0.75% Mo.

Metallographic examination of transverse sections of the plate assemblies welded with the pearlitic steel electrodes, the above Types A, C and D, showed the following for all weldments, regardless of the variations given for the preheat and interpass temperatures in Table 1.

The weld metal, with the exception of the seal beads, was fine grained and equiaxed. The heat-affected zones of the base metal adjacent the lines of fusion were also fine grained, having been fully refined by the repeatedly applied thermo-cycle of welding. The photomicrographs on Fig. 3 show typical portions of the unaffected base metal, the transition zone, the fusion zone and the weld metal of Type D electrode, at 100 magnifications.

A review of Table 1 indicates that the electrode yielding weld metal whose physical properties approach most closely those of the base metal, particularly as regards torsional fatigue endurance, is the above Type D which yields a 0.3 Cr, 1.00 Ni, 0.75 Mo alloy.

Thus the first phase of the investigation was completed in regard to the selection of an electrode on the basis of physical properties.

The next step was to determine if the electrode selected as most suitable, as regards the physical properties of the weld metal it deposits, is readily applicable to weld shafting varying from 6 to 20 in. in diameter.

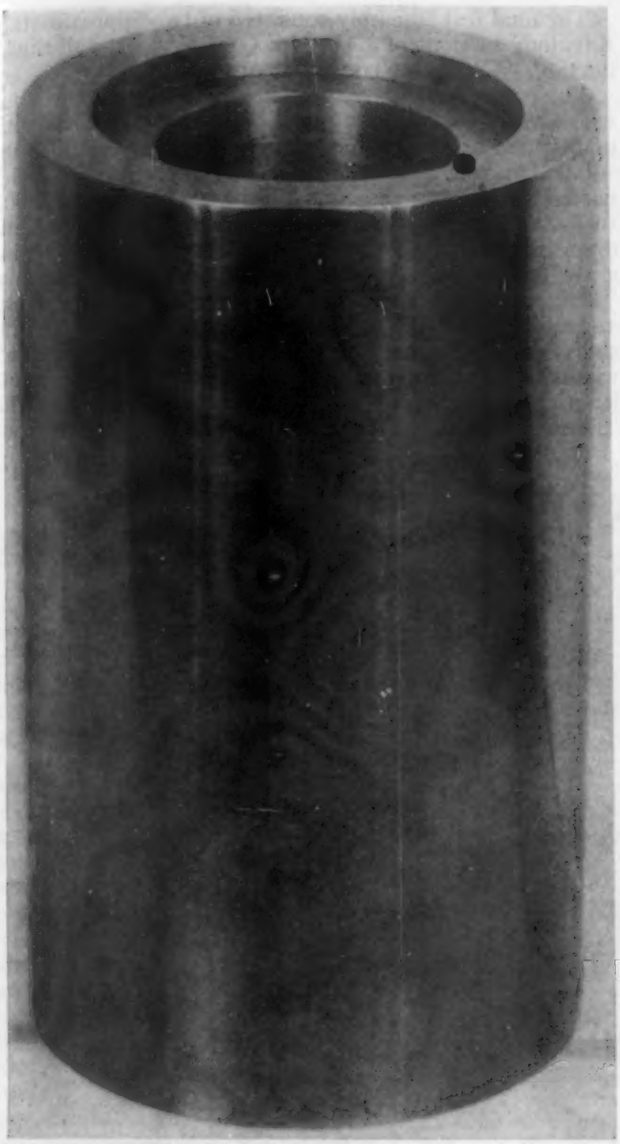


Fig. 1

Development of Welding Procedure and Appliances

The development of welding procedure was started by fabricating joint assemblies employing 7-in. diameter Class An, $3^1/_2\%$ nickel steel shafting of 3-in. bore. In fabricating several assemblies of the above size the effect of each of the following variables was evaluated:

(*a*) Type of current to be used.
(*b*) Electrode performance affected by the joint design.
(*c*) Electrode performance as affected by the rotating apparatus.
(*d*) The applicable method for preheating and stress relieving in place.
(*e*) Method of deposition as a means to control warpage.
(*f*) Method of assembling the joint and its effect on final warpage.

Based on the results of the tests given in Table 1, all welding was performed using the electrodes identified above as Type D, employing a 500° preheat and interpass temperature.

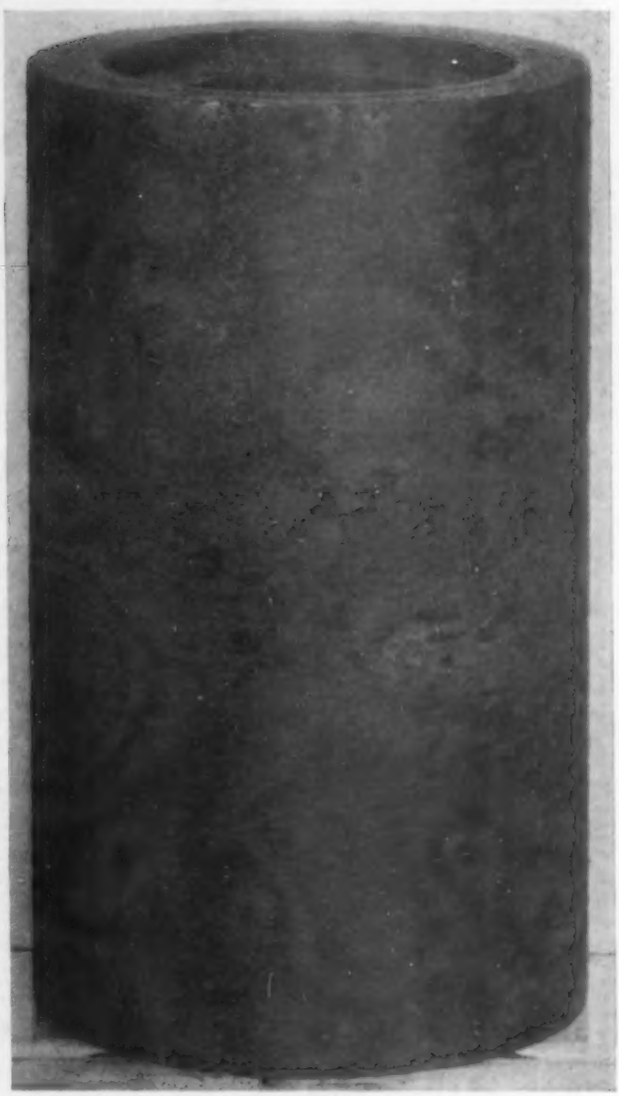
The results of the tests performed in welding the 7-in. diameter assemblies were as regards the above listed variables as follows:

(*a*) Using d.-c. power considerable arc blow was experienced in the deep grooves. Employment of a.-c. power eliminated arc blow.

(*b*) The joint shown on Fig. 4, presents a 30° included angle for the radial length of 1 in. from the bottom of the groove, whence the divergence is reduced to 14°. This design was evolved to permit unhampered manipulation at the bottom of the groove.

(*c*) Correlation of Arcronograms and destructive tests showed that the major arc disturbances were caused by jerkiness of the electric drive of the rotator. Substitution of a hydraulic drive, capable of instantaneous and stepless regulation, solved the above problem.

(*d*) The Engineering Experiment Station design, articulated, fixed pitch induction coils were found satisfactory for preheating, maintaining the desired interpass temperature and for postheat treating. The independently mounted coils permitted free rotation of the weldment in either direction. The temperature difference between the outer and inner surfaces was found to be negligible for all wall thicknesses employed in the test, ranging from 2 to $5^1/_2$ in.



× 1.0

Fig. 2

(*e*) It was established that by staggering the increments during the development of the first few passes warpage can be readily controlled within reasonable limits. It was also found that, after the depth of the deposit exceeds 1 in., staggering the increments has no further effect in correcting warpage.

(*f*) The tests showed that the most effective method for controlling warpage is shrink fitting the machined ends to be joined upon the heavy "Dutchman," which also serves as the backing ring. To counteract the possibly harmful effect of the extreme stiffness of the above type assembly, weldments, whose wall thickness exceeds 2 in., are stress relieved, after approximately one-half of the depth of the groove has been filled in by welding. Then, on completion of the weld the weld zone is given another stress-relief treatment, whose duration is computed on the full thickness of the weld.

The final test assembly consisted of two approximately 6-ft. long sections of a $17^{5}/_{8}$-in. O.D., $5^{1}/_{2}$-in. wall thickness, $3^{1}/_{2}$% nickel, Class An steel shafting.

The ends of the above sections, beveled in accordance with the design shown on Fig. 4, were bored out to a depth of 6 in. to a given dimension and with a +0.0015-in. −0.000-in. tolerance. The $12^{1}/_{2}$-in. long mild steel billet used as a backing ring was turned to a diameter 0.003 to 0.005 in. larger than the new bores in the $17^{5}/_{8}$-in. diam. shafting. To assemble the joint first one $17^{5}/_{8}$-in. shaft end was heated to 600–700° F. and the above "Dutchman" was inserted. When the above subassembly cooled to room temperature, the other $17^{5}/_{8}$-in. shaft end was heated and slipped onto the "Dutchman" which was machined with a $^{1}/_{2} \times {}^{3}/_{32}$-in. groove at mid-length. This groove served as an aid in locating the "Dutchman" in the bore and to assure that the root

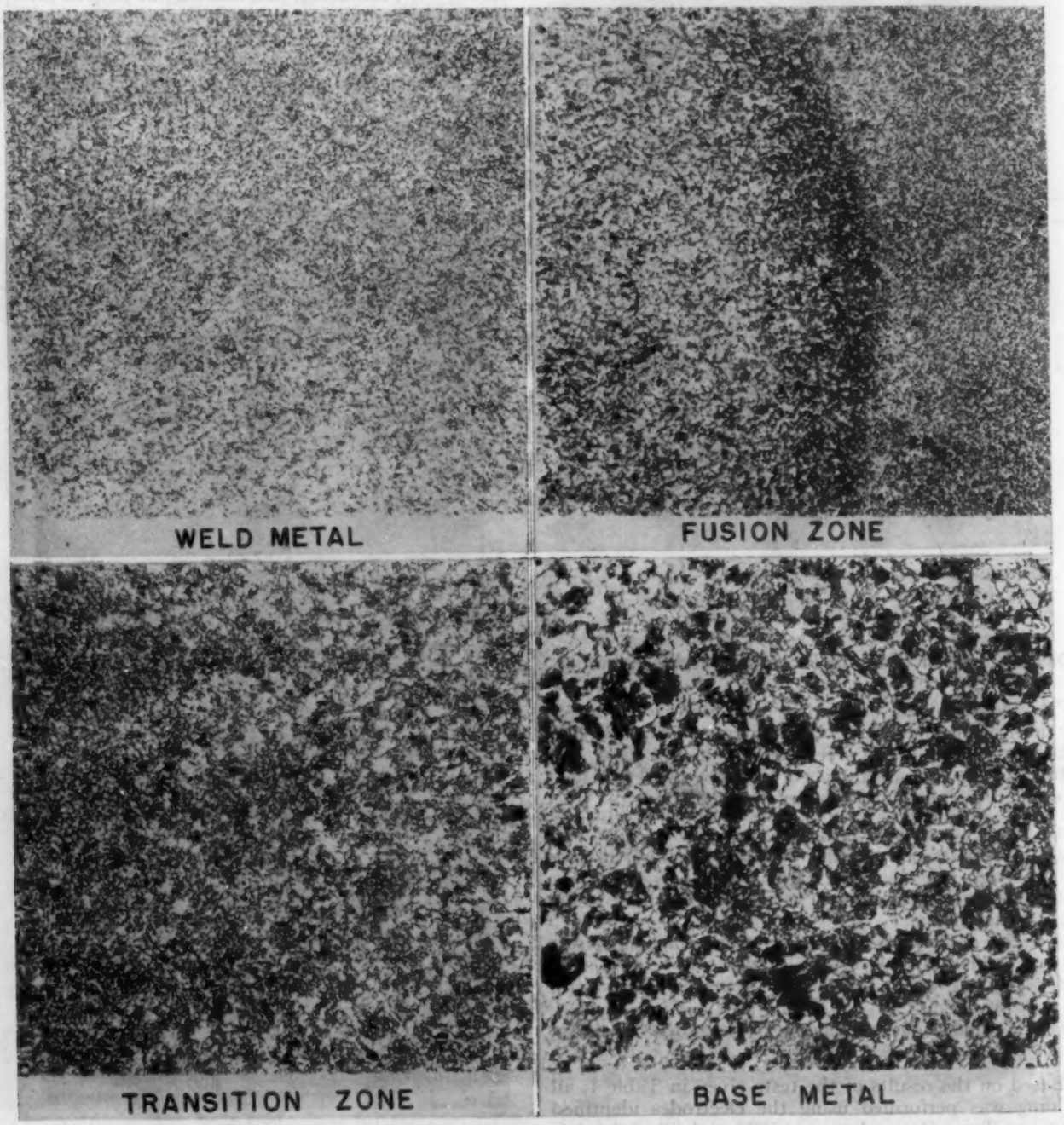
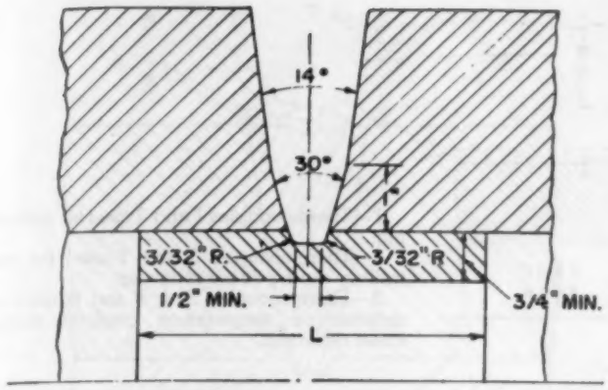


Fig. 3



L = I.D. OF BORE (NOT LESS THAN 8").

Fig. 4

spacing was $^1/_2$ in. as desired. Further, the fact that the "Dutchman" was of low-carbon steel prevented cracking of the first pass by eliminating carbon and nickel pickup. Preheating was performed by three separately powered induction coils which having been independently mounted, permitted free rotation of the shaft. Details of induction coils similar to the above type are shown on Fig. 5. The shaft was insulated against heat loss as indicated on Fig. 6A.

Each of the three 10-turn induction coils were connected to a separate transformer. Units 1 and 3, the end coils, were powered from the secondaries of two 30-kw., 220/30 single-phase transformers. The middle section, also of 10 turns, was connected to the 30-v. secondary taps of a $37^1/_2$-kw., 220-v. primary, single-phase transformer. The primaries of the three transformers were connected to a three-phase, 220-v. power line in such manner that the load was properly balanced on all phases. Preheating was controlled by thermocouples welded, before assembling, in the bores of the backing ring and shaft sections, respectively, as shown on Fig. 6A. The control apparatus was a specially designed automatic temperature program controller. Welding was started after the zone to be welded had been held for not less than $^1/_2$ hr. at 500° F.

Deposition started with $^5/_{32}$-in. diam. Type D electrodes which were supplanted by $^3/_{16}$-in. and later $^1/_4$-in. diam. sizes in rotation; the criterion to change to a larger electrode size has been the presence of a full slag covering on all increments. All deposition was recorded by Arcronograms which were scrutinized on completion on each pass. The deposition was recorded on a circular chart which was correlated with markings on one end of the shaft. Arc irregularities indicated by the Arcronograph were immediately located and marked on the above circular chart. The ends of the shaft were marked with divisions spaced at 45°. These, and reference to the indicator mounted over a portion of the shaft which was trued after assembling, were used in alignment control. Realizing the inherent danger of the stiffness of the assembly when approximately one-half of the $5^1/_2$-in. deep groove was filled with weld metal, deposition was stopped and the weld was stress relieved at 1175° F., which temperature was held for 6 hr. Under automatic temperature control the weld zone was permitted to cool at the rate of 150° per hour to 500° F., when welding was resumed. On completion of the weld it was again stress relieved, being held this time for 12 hr. at 1175° and cooled to 300° F. under automatic control, and then to room temperature at the natural rate, but still within the insulation. In filling the groove deposition was controlled to prevent the formation of layers or passes from being heavier than 0.1 in. This was accomplished by regulating the peripheral speed for each of the electrode sizes used and readjusting the speed of rotation as the radius of the deposit increased. Since the current rates applied were at the middle of the respective ranges of the various size electrodes employed variation of the transformer setting was neither needed nor applied.

The method used to reconvert and refine the upper stratum of base metal adjacent the seal beads is indicated by the sketch on Fig. 7 and the macrographs on Fig. 8. Accordingly, after the weld is filled flush with the outer surface of the weld, a normal seal bead is deposited in such manner that it straddles both weld and base metals. The heat effect of this seal bead refines the portion of the base metal coarsened by the heat input of the last pass of weld metal deposited within the joint proper. Another, smaller seal bead superposed on the first tempers the previously refined portion of the base metal and aids in restoring its original ductility.

The completed joint was stress relieved in place, using three coils of ten turns each, as described above.

The three transformers were controlled by means of a thermocouple attached to the outer surface of the weld, as shown on sketch, Fig. 6A. This sketch also presents the number and location of the additional thermocouples installed. The latter were installed for the purpose of furnishing information concerning heat distribution. The records obtained from the use of the above additional thermocouples showed that the use, distribution and

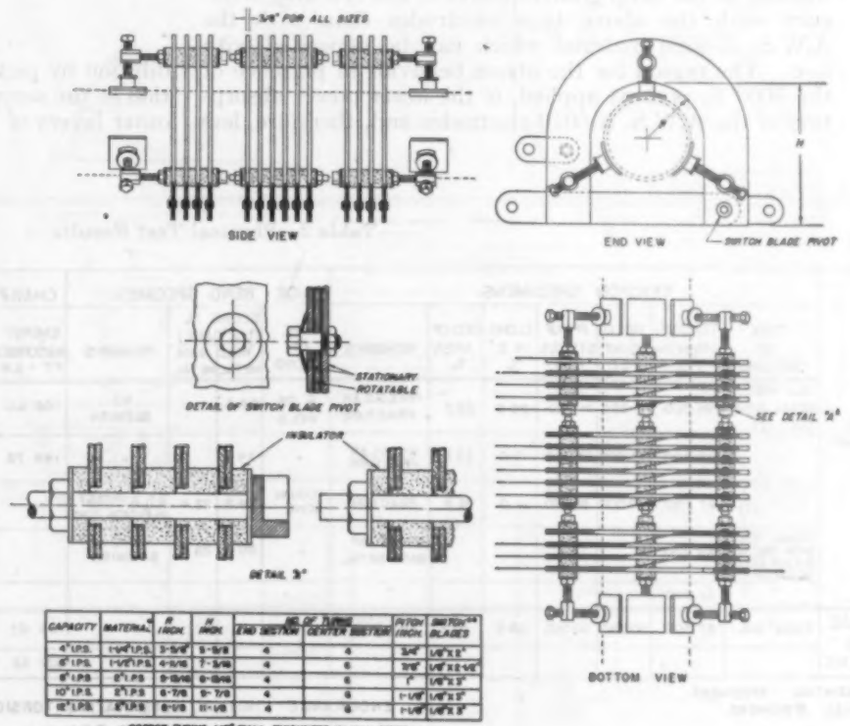


Fig. 5

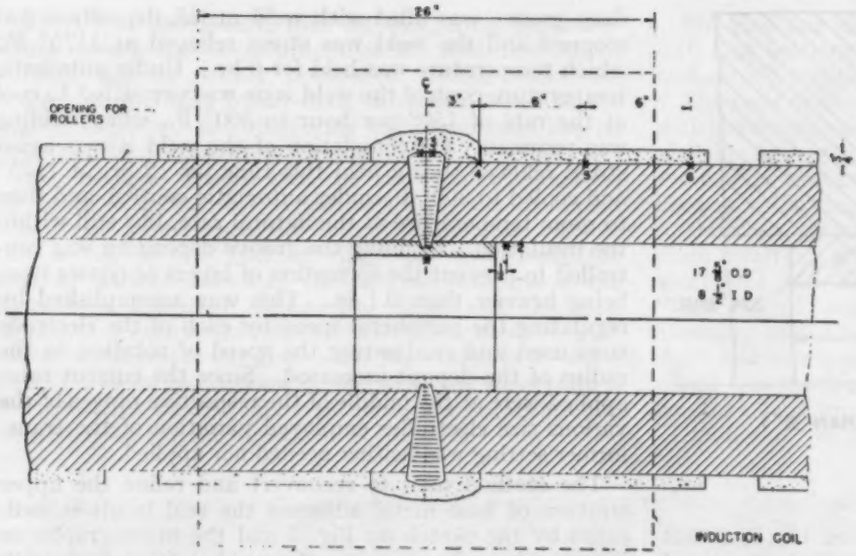


Fig. 6A

1—Thermocouples 1 and 2 used for preheating.

2—Thermocouples 3 and 7 used for controlling during stress relieving.

3—Thermocouples 3, 4, 5 and 6 used for determining temperature gradient during stress relieving.

method of application of the insulating materials shown on Fig. 6A were fully justified.

The stress-relieved joint was cut out and dissected as indicated on Fig. 9. The results of the tests performed for the specimens fabricated from the above joint are given in Table 2.

Inasmuch as the repair of propeller shafting includes the rehabilitation of corrosion cracks, worn key-ways and the elimination of plug holes, methods were worked out to perform the above operations.

Figure 10 shows the recommended groove design for repairing circumferential cracks in shafting. In welding these grooves it is mandatory that the first two passes be deposited from mild steel electrodes of the A.W.S. E-6010 type. Experience showed that regardless of the added difficulty of applying d.-c., reversed polarity welding in the deep grooves, there is less cracking tendency with the above type electrodes than with the A.W.S. E-6020 material which can be deposited with a.-c. The reason for the above behavior in presence of the 500° F. preheat applied, is the lower power absorption of the A.W.S. E-6010 electrodes and, therefore, less

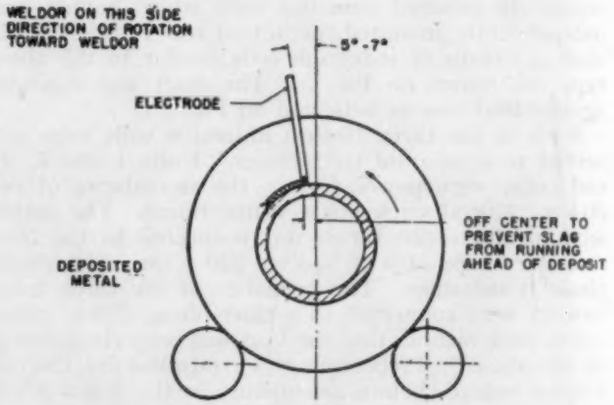


Fig. 6B

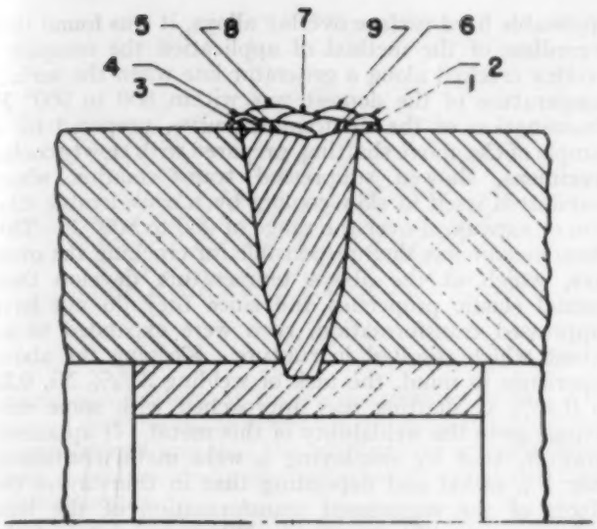
dilution by pickup from the base metal. The superposition of the secondary seal beads to refine and temper the outer layers of base metal adjacent the weld, applied in

Table 2—Physical Test Results

	TENSION SPECIMENS							SIDE BEND SPECIMEN				CHARPY IMPACT TENSION SPECIMENS				NOTCHED CHARPY SPECIMENS		
	TYPE OF SPECIMEN	TENSILE STRENGTH PSI	YIELD POINT PSI	PROOF STRESS PSI	ELONG IN 2" %	RED. OF AREA %	REMARKS	TYPE OF BEND	ELONG % (1/2" GAGE) WELD METAL	ELONG % (1/2" GAGE) BASE METAL	REMARKS	ENERGY ABSORBED FT.-LB	ELONG. IN 2" %	RED. OF AREA %	REMARKS	LOCATION OF NOTCH	ENERGY ABSORBED FT.-LB	REMARKS
WELD SECTION	ALL WELD METAL 0.505" DIA. (2)	86 000	71 300	71 250	20 0	52.7	IRREGULAR FRACTURE	℄ OF WELD	24.5		NO BLEMISH	186 60	20.5	59 6	TRANSVERSE SPECIMEN BROKE IN BASE METAL NEAR GAGE MARK.	℄ OF WELD	31 30	NO BLEMISH
	"	86 500	73 600	73 750	13.0	33 8	ANGULAR FRACTURE	"	24 4		"	144 78	15.0	56.8	"	"	38.75	"
	" (1)	97 250	87 000	85 000	21.0	56.8	CUP FRACTURE	FUSION ZONE	24.5	22.4	1/4" x 1/4" DEFECT IN FUSION ZONE					FUSION ZONE	38 38	ONE SMALL DEFECT
	TRANS. TENSION RECTANGULAR CROSS SECTION	84 100					BROKE IN BASE METAL	"	20.4	28.0	NO BLEMISH					"	48.48	NO BLEMISH
	"	81 000					"											
ALL BASE METAL SPECIMENS	0.505" DIA.	87 500	50500	50 500	28.5	52.2	CUP-LIKE FRACTURE					194 07	26.0	55.7	CUP-LIKE FRACTURE BROKE NEAR GAGE MARK		24 69	COURSE GR FRACTURE
												231 33	31 5	58 5	CUP-LIKE FRACTURE		25. 83	"

(1) TANGENTIAL SPECIMENS
(2) RADIAL SPECIMENS

ENDURANCE LIMIT IN ALTERNATING TORSION
BASE METAL: 18,000 P.S.I.
TRANVERSE WELD: 16,000 P.S.I.



SEAL BEADS
1-4 = 5/32" DIA. ELECTRODE
5-9 = 1/4" DIA. ELECTRODE

Fig 7

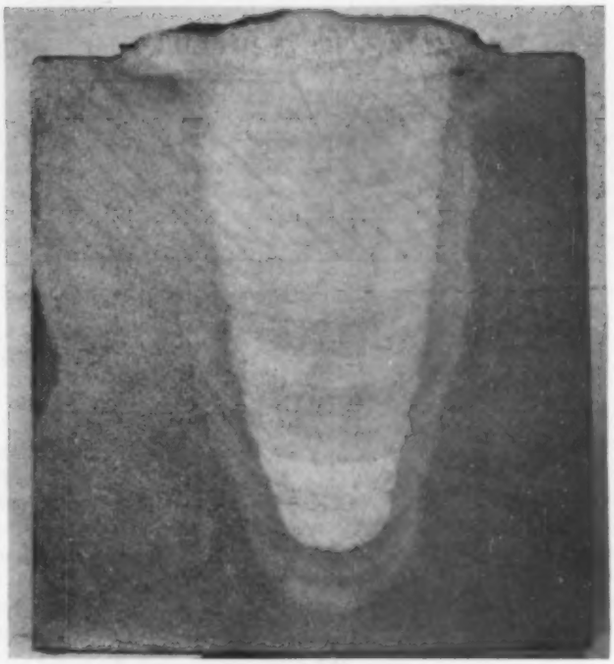


Fig. 8

joining shaft sections is also marked as a "mandatory" procedure.

The methods designed to repair worn key-ways and plug holes are illustrated in Figs. 11 and 12. These indicate the selection of electrode sizes and the method of progression, respectively. Noteworthy is the use of run-out plates in welding up worn ways which permit building up the shaft ends to permit squaring to the original dimensions.

On completion of the above investigation all pertinent information was made available, through the Bureau of Ships of the Navy Department to such Navy Yards and private contractors who were designated to repair propeller shafting. The information pertained to the following:

(*a*) Procurement of electrodes.
(*b*) Applicable current rates.
(*c*) Joint design.
(*d*) Welding procedure complete with directions as regards electrode manipulation, direction of rotation, pass sequence, thickness of increments, temperature control, alignment control, heat insulation of the weldment, preheat, interpass and stress relief control, use of thermocouples and method of applying seal-beads.
(*e*) Design for fabricating rotators.
(*f*) Information concerning the procurement of induction heating equipment.
(*g*) Information concerning procurement of automatic program controller for pre- and post-heating.

Using the above information the activities authorized by the Bureau of Ships of the Navy Department equipped themselves with the specified devices and proceeded to train crews in the performance of this highly specialized welding procedure. When they were satisfied with the proficiency of their crews, i.e., after having performed their own tests, they prepared a welded joint, employing 14 to 18-in. diam. shaft sections and submitted it together with all pertinent welding data which included a

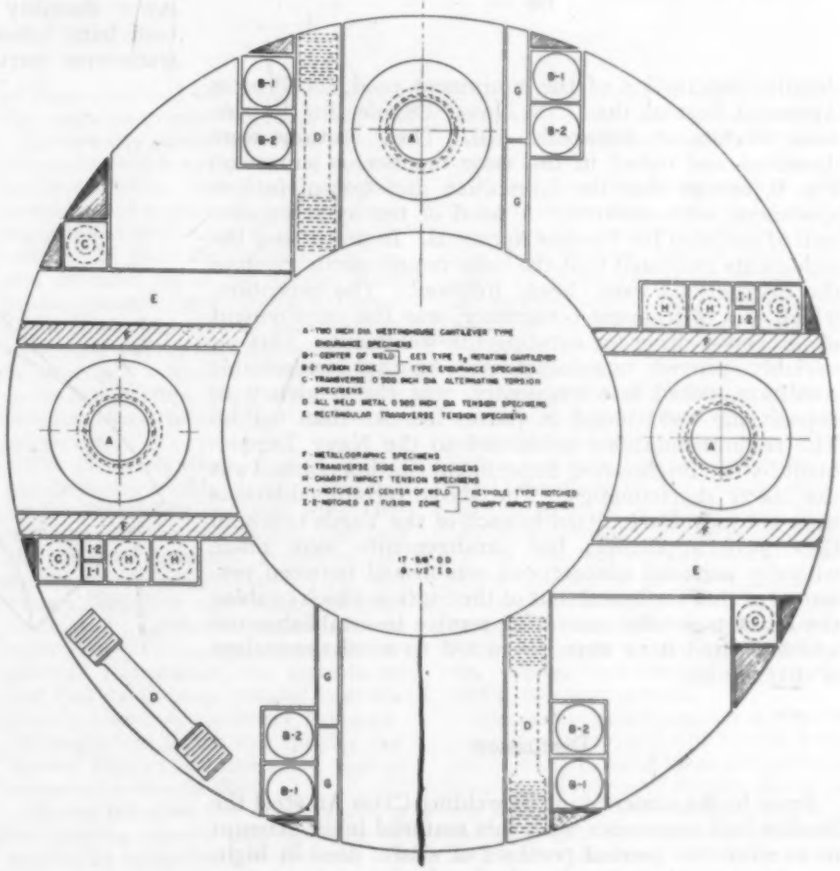


Fig. 9

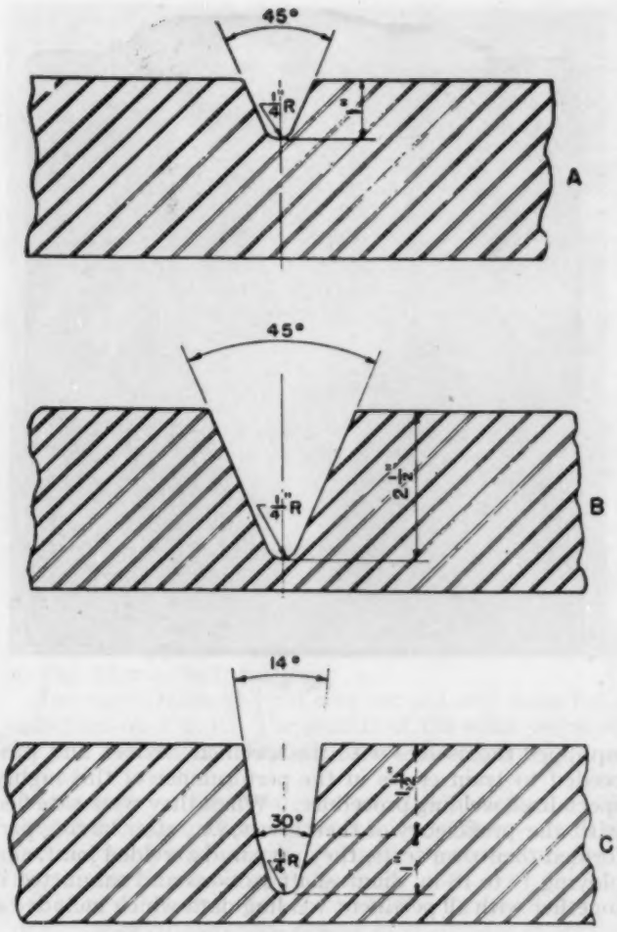


Fig. 10

detailed description of the equipment used, for Process Approval Test at the U. S. Naval Engineering Experiment Station at Annapolis, Md. These sections were dissected and tested in the same manner as shown on Fig. 9, except that the fabrication and test of fatigue specimens were omitted. A total of ten agencies submitted material for Process Approval. In most cases the weldments indicated that the basic requirements given in the instructions were closely followed. The exception, which was of frequent occurrence, was the employment of air power drive for rotating the weldment. This invariably proved unsatisfactory. Another undesirable condition, noted less frequently, was the tendency to deposit the weld metal in passes heavier than 0.1 in. The recommendations submitted to the Navy Department by the Engineering Experiment Station pointed out the above shortcomings. The above recommendations were not only transmitted to each of the Yards to whom they were applicable, but arrangements were made whereby personal contact was established between personnel of the Yards and that of the Station which enabled the latter to render consulting service to establishments which desired it or were instructed to avail themselves of that service.

Discussion

Prior to the undertaking of welding Class An steel the Station had experience with this material in an attempt to overlay the journal portions of shafts used in high-speed rotary devices. Employing in rotation, various applicable hard surface overlay alloys, it was found that regardless of the method of application the completed overlay cracked along a generator line when the surface temperature of the deposit was within 800 to 900° F. Examination of the dilatometer curve, prepared for a sample of the above shafting, prepared with slowly cooled specimens, showed suppressed transformation which manifested itself in slow cooling by a considerable dilation or expansion over the range of 900 to 800° F. This phenomenon was then responsible for cracking the overlays, which at the above temperature develop their normal elastic properties and since they do not have suppressed transformation, then were expanded to an extent which resulted in rupture. Keeping the above experience in mind, the task of welding 3½% Ni, 0.35 to 0.45% C shafting was approached with some misgivings as to the weldability of this metal. It appeared, however, that by employing a weld metal containing only 1% nickel and depositing that in thin layers the effects of the suppressed transformation of the base metal were readily overcome. When, in course of the preliminary work performed to evaluate the applicable electrode, a brand depositing 2½% nickel was used, cracking was too frequently encountered regardless of the thickness of each pass or layer. It is notable, however, that the cracks were always longitudinal through the center of the deposit and at no time was either underbead or the so-called cold cracking noted.

In developing the test procedure a weldment was fabricated wherein the thickness of the individual increments was permitted to exceed 0.1 in. Microscopic examination of transverse sections of the above weld showed that regardless of the thickness of the superposed beads, the lower portion of the beads or passes whose thickness exceeded 0.1 in. was left in the as-deposited, dendritic condition. Test bars fabricated from this weldment, which were cut radially, showed considerably lower ductility than those taken tangentially. The test bars taken from the radial position developed transverse corrugations in being tested to destruction.

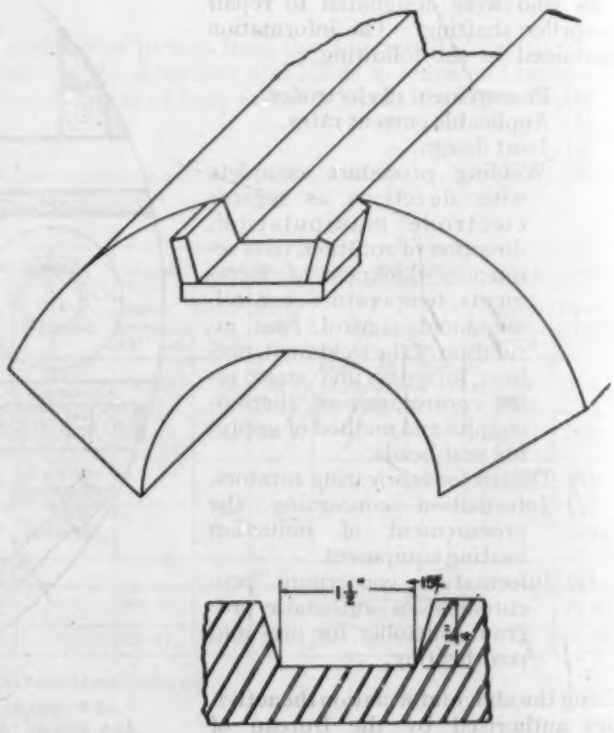


Fig. 11

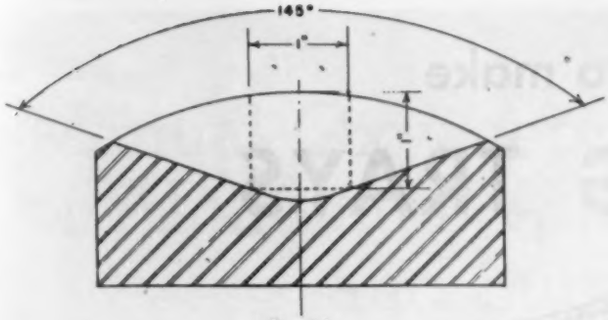


Fig. 12

Macro-examination of transverse sections of the latter showed that the metal within the convex corrugations was coarse grained and that the concave corrugations, which were miniature neckings, contained material of refined grain structure.

Hardness surveys performed for the above sections, using appropriate apparatus, indicated comparable values for both the coarse-grained and the refined components. From the above it appeared that the yield point of the weld metal in the dendritic condition, regardless of its hardness, is higher than that which is in the refined grain state. In order to determine whether or not the above hypothesis is true the following was performed. A large section of the weldment was normalized, after the performance of preliminary studies, from 1750° F. and drawn at 1175° F. Examination of sections of the so-treated weld metal showed that it was completely homogenized and all traces of the dendritic striations have disappeared. Tests made for all-weld metal tension bars cut radially from the above heat-treated section gave the following results:

Tensile strength = 105,200 psi.
Yield point = 91,200 psi.
Elongation % in 2 in. = 17.0
Reduction of area = 42.0

It is noteworthy that this 0.12% C weld metal has responded to the normalizing treatment contrary to experience which showed no such response for mild steel or C-Mo weld metal. The information was of further importance in that it proved that welded shaft sections can be reheated if and when desired, without fear of loss of the original physical properties.

Summary

The investigation related above resulted in the development of a procedure to weld 0.35–0.45% C, 3½% nickel shafting normalized and drawn to the minimum tensile strength of 80,000 psi., in such manner that the physical properties of the welded joint are fully comparable with those of the unaffected portions of the base metal. The procedure was effected by giving equal weight to all factors, namely, metallurgical and technological in evolving it and by impressing the supervisors in charge of training crews for shaft welding, of the importance and significance of each of the variables and advising them not to relax their vigilance nor to delegate control or supervision of this operation which though well controllable, remains delicate by virtue of its importance. Propeller shaft failure in war as in peace must be avoided.

The above paper presents the author's views and opinions which are not necessarily those of the Navy Department.

LINCOLN FOUNDATION ANNOUNCES $200,000 AWARD PROGRAM

The James F. Lincoln Arc Welding Foundation today announced a $200,000 Award Program for technical papers as a means of encouraging further scientific progress in the arc-welding industry.

In making the announcement, E. E. Dreese, head of the Ohio State University Department of Electrical Engineering and trustee chairman of the Foundation, had his words put down on a shining, stainless steel plate. The penman was an experienced arc welder who used molten weld metal for the ink and the welding arc for a pen.

The award program closes in one year, at midnight June 1, 1947. Rules and conditions governing the activity may be obtained from the Foundation Secretary, Cleveland 1, Ohio.

Dr. Dreese pointed out that there would be 452 awards in the "Design-for-Progress" program covering every field of application and research for electric arc welding with awards ranging from 217 awards of $100 each for honorable mention to the principal award of $13,200 for the paper judged best of all submitted. He said that the program would not only be open to scientists and engineers, but that possible participants would also include production and maintenance men, shop superintendents, foremen, and workers of all kinds connected with industrial or private operations, research or education.

To tap every possible source for ideas on arc welding which will lower costs or make for better living, Dr. Dreese said that awards would be made in 15 broad classifications and 43 divisions of those classifications. In 11 of the classifications, papers are called for on the redesign of an existing machine, structure or fabricated product, which previously was made in some other way, so that arc welding may be or actually is applied in whole or part to the manufacture. New design of such products also is to be subject matter for the papers.

The 11 classifications, all with numerous divisions, in this group enumerated by the Foundation chairman were: aircraft, automotive, containers, furniture and fixtures, functional machinery, industry machinery, personal service machinery, buildings and bridges, railroad, houses and miscellaneous structures, and watercraft. Taking the "personal machinery" classification, for example, he said that its divisions included farm machinery, household machinery, food-making machinery, textile and clothing machinery, printing machinery and machinery not otherwise classified.

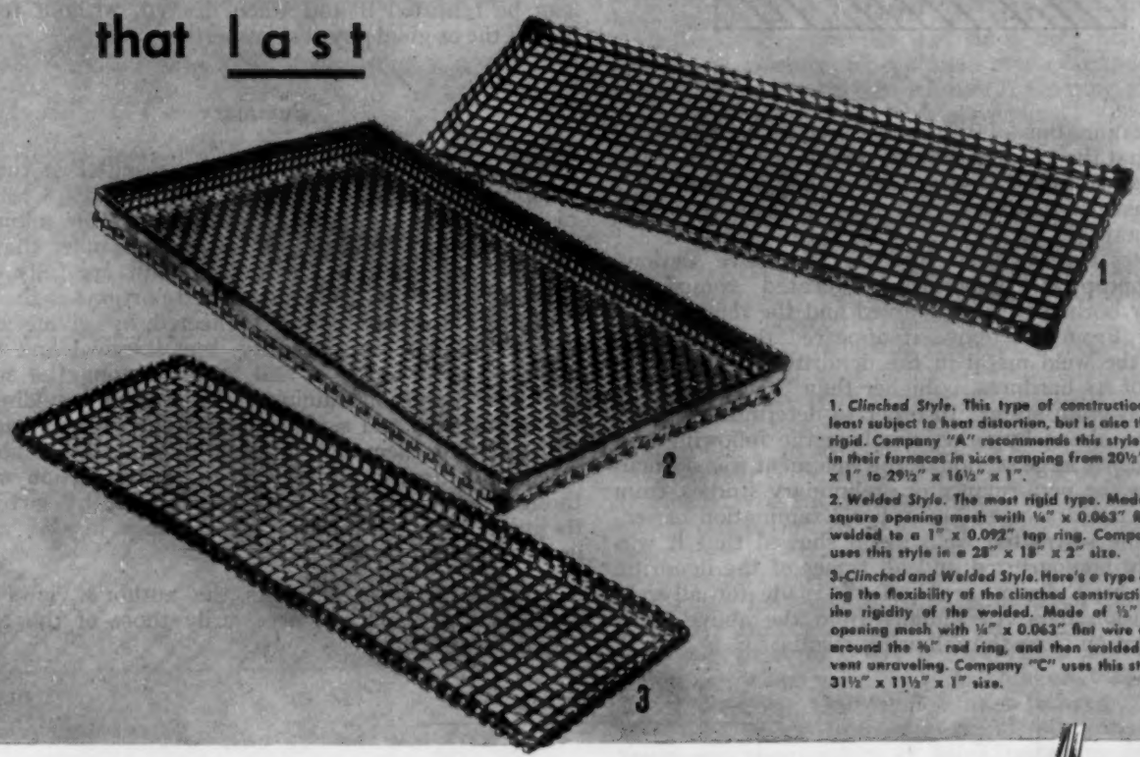
Among the other four classifications is one covering research work applied to arc welding by industrial, governmental, private and college laboratories, according to Dr. Dreese. It also is said to extend to the field of college engineering education having to do with best methods for teaching arc welding.

Of the other three classifications listed in the award program, one calls for papers describing the successful operation of all phases of a weldery; another covers operations by commercial welders or job shops and garages; and the third classification is for papers on arc welding as applied to maintenance work on all types of machinery or structures.

Awards of $700, $500, $250 and $150 go to the best papers in each of the 43 divisions, the program rules state. The judges then select the four best papers in the 15 classifications and these awards in each group are to be $2500, $1500, $1000 and $800. Finally, the papers are judged for the three best of all submitted. These top awards are to be in the amounts of $10,000, $7500 and $5000. Dr. Dreese said the 217 honorable mention awards of $100 each would be made on the merit of the papers, regardless of divisions in which they were entered.

The current award program typifies the consistent activities of The Lincoln Foundation which included the awarding of cash amounts to writers of winning papers on the preparation of textbooks, on farming, and on practically all types of commercial and industrial progress involving welding processes.

3 Ways to make BRAZING TRAYS that last



1. *Clinched Style.* This type of construction is the least subject to heat distortion, but is also the least rigid. Company "A" recommends this style for use in their furnaces in sizes ranging from 20½" x 6½" x 1" to 29½" x 16½" x 1".

2. *Welded Style.* The most rigid type. Made of ¼" square opening mesh with ¼" x 0.063" flat wire welded to a 1" x 0.092" top ring. Company "B" uses this style in a 28" x 18" x 2" size.

3. *Clinched and Welded Style.* Here's a type combining the flexibility of the clinched construction with the rigidity of the welded. Made of ½" square opening mesh with ¼" x 0.063" flat wire clinched around the ⅜" rod ring, and then welded to prevent unraveling. Company "C" uses this style in a 31½" x 11½" x 1" size.

All - INCONEL brazing trays show longer life at the high temperatures used in brazing

Thermal endurance, strength, ductility and *resistance to oxidation and corrosion* are the properties that make Inconel* "standard" for many high-temperature applications.

And, here you see how Inconel goes to work to make long-lived brazing trays that cut replacement and minimize operating interruptions.

The trays shown represent the three principal types of construction supplied to order by ROLOCK, INC. of Fairfield, Conn. Used at brazing temperatures of 2050° F., these all-Inconel trays have outlasted and out-performed other materials previously used. In fact, all through brazing equipment, you'll find parts being made of Inconel . . . to ensure long, trouble-free service.

For more information on the metal that fights high heat . . . oxidation . . . corrosion . . . mechanical abuse . . . write for your copy of *"For Long Life at High Temperatures."* The International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y.

*Reg. U. S. Pat. Off.

INCONEL—for long life at brazing temperatures

(80 NICKEL-14 CHROMIUM)

Manual Oxyacetylene Flame Brazing of Aluminum, Aluminum Alloy Sheet and Subassemblies

By F. Clark, M.B.E., Inst.W.*

THOSE familiar with fusion welding of light gage aluminum sheet will appreciate the difficulties often encountered when welding is specified for joints near edges such as narrow fillet or close corner joints. Fusion welding under such conditions is at best very difficult, due to the melting back of one or both edges. Blueprints of small subassemblies often indicate a fillet weld with a short upstanding edge fully retained, a joint that is almost impossible to execute and calls for the highest degree of welding ability.

It will certainly be appreciated that recommendations for fusion welding indicate that butt welds should be arranged wherever possible, and so eliminate fillet or lap welds which cause flux entrappage. The reason should be obvious, namely, that surplus flux trapped in a joint which is not completely scaled cannot be removed by ordinary washing or scouring methods. Flux so entrapped will cause corrosive attack of the weld or parent metal near the weld and consequent breakdown of the structure in perhaps a few weeks.

The arrangement of butt joints in place of fillet or lap joints is not insuperable, but calls for careful thought in design. Such rearrangement, however, usually means additional operations and consequently increase in cost of production; and again, there may be times when some form of fillet or lap joint cannot be avoided.

These troubles can be largely overcome by the use of silicon aluminum filler rods and flame brazing; especially in the case of smaller assemblies, such as fabricated brackets, etc., or where small parts such as sheet flanges have to be joined to tubes. This process has the advantage that the low melting point filler metal percolates around and into the joint driving out flux which would otherwise become entrapped; and more particularly eliminates the danger of melting away edges or projections which must be retained in their correct profile or condition. Figures 1, 2 and 3 are views of extruded section joints which illustrate the neatness of joints obtainable. The latter photograph shows a mirror reflection of the oppo-

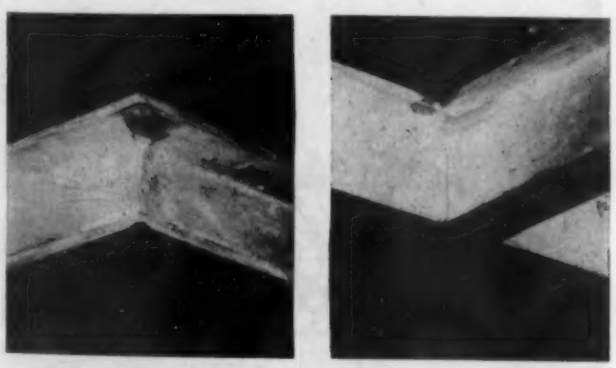


Fig. 1—Flame-Brazed Extruded Section Elbow and Tee Joints in Aluminum-Magnesium Alloy

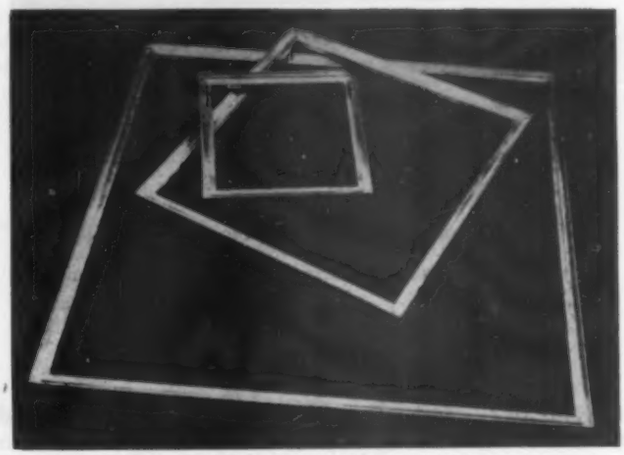


Fig. 2—Brazed Corner Joints in Extruded Section Frames

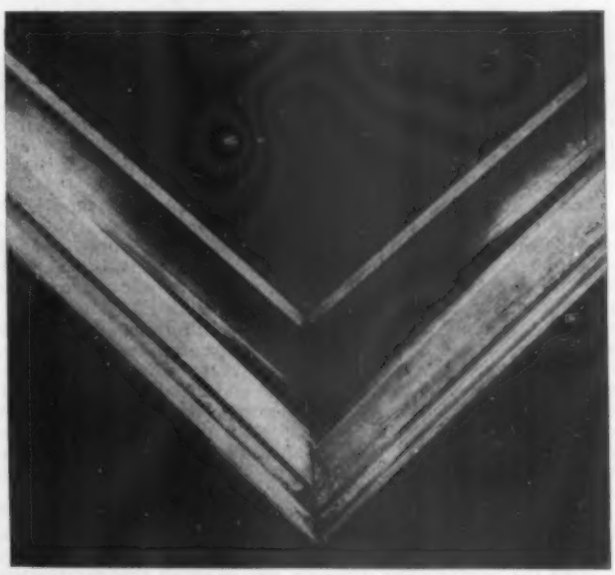


Fig. 3—Extruded Section Corner Joint with a Mirror Reflection of the Opposite Side of the Joint

* Superintendent General Service Section, British Oxygen Co., Ltd., London, England.

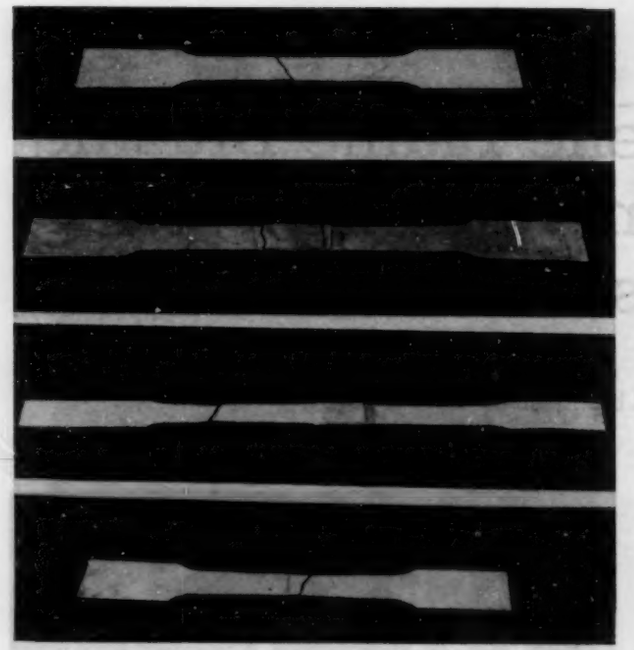


Fig. 4 (Top)—Parent Sheet Specimen in Fully Hardened Condition
Fig. 5 (Second)—Lap Joint Specimen Fractured at 6.73 Tons/Sq. In.
Fig. 6 (Third)—Lap Joint Specimen Fractured at 6.20 Tons/Sq. In.
Fig. 7 (Bottom)—Lap Joint Specimen Fractured at 5.77 Tons/Sq. In.

site side of the joint shown in the foreground. Manual flame brazing is a relatively simple operation if attention is paid to certain fundamental principles.

Parent Material

[EDITORIAL NOTE: Inasmuch as our readers may not be familiar with the American alloys corresponding to the British designations, the following explanation may be helpful. Unfortunately, it will not be possible to indicate a truly equivalent American alloy in most cases, since the British composition limits define a slightly (or significantly) different alloy.

Specifications L4, L16 and L17 cover commercially pure aluminum sheet in the hard, half-hard and annealed conditions, respectively. The material approximates Alcoa 2S and the strengths required for the three tempers are about the same as for 2S-H, 2S-$^1/_2$H and 2S-O. The British, however, permit the iron plus silicon content of the material to be as much as 1.75% (we limit it to 1% in this country) and they specify a minimum of 98% aluminum while we call for at least 99%. Specification L46 covers a range of alloys containing from 1 to 6% magnesium and permitting up to 1.5% (each) of iron, manganese and nickel. Several American alloys would come within the composition limits and about meet the specified tensile properties: Alcoa 52S-O and Alcoa 53S-W are examples. From the author's remarks on the preferred magnesium range, one might assume he was referring to an alloy very similar to Alcoa 52S-O.

Specification DTD-346 covers an alloy containing about 1% silicon, 0.9% magnesium and 0.75% manganese. There is no commercial American alloy of this composition on the market, although the prewar alloy Alcoa 4S was of about this composition. DTD-213A corresponds very closely with Alcoa 3S-$^1/_4$H sheet and the two could be considered interchangeable. In this connection, it should be noted that the mechanical properties requirements for DTD-346 and DTD-213A are the same, indicating that the British may consider them interchangeable.]

Brazing has been employed on commercial aluminum and to a lesser extent on some types of alloy. The commercial material of the L4, L16 and L17 type is brazed most readily. Aluminum-magnesium alloys within L46 specification can be brazed satisfactorily, provided the magnesium content is not more than 3% and preferably less than 2%. The same remarks are true of the aluminum-manganese magnesium alloys, e. g., DTD-346 and aluminum-manganese-alloys, e.g., DTD-213A. These alloys will, however, return to the equivalent of an annealed temper regardless of the amount of cold work in production prior to brazing, although some slight additional strength may be induced by cold water quenching after brazing. It has been claimed that other alloys capable of being heat treated, containing small percentages of manganese-magnesium and chromium, produce joints of a relatively high strength, and it is stated they attain maximum strength after subsequent appropriate heat treatment.

Filler Material or Brazing Rod

The filler material or brazing rod must have a lower melting point than the parts to be joined. It must be clean and smooth flowing in action, with good penetrative or "wetting" powers which cause it to flow into and around the joint readily as soon as its melting point is reached. It must do this before the temperature in the parent part causes sagging or plasticity. Such a rod is a straight silicon aluminum alloy containing 10 to 12% silicon, and which has good mechanical properties.

Experimental rods of a eutectic type, i.e., copper-silicon-aluminum with a much lower melting point have been used, and they make the brazing operation much easier. Various questions arise in connection with their

Fig. 8—Micrograph of "Fillet." 50 ×

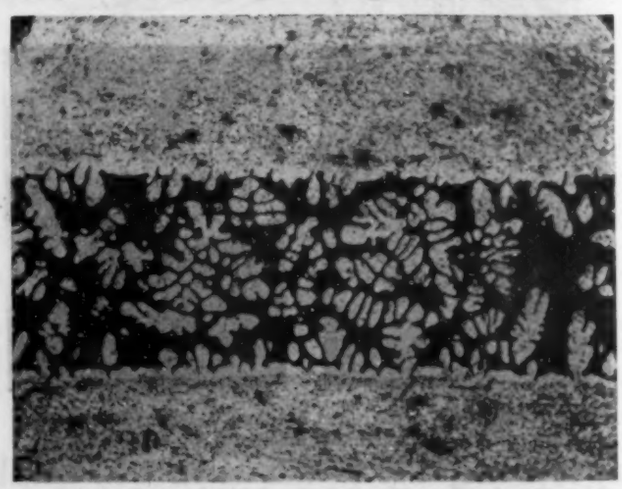


Fig. 9—Micrograph of Penetrated Metal. 100 ×

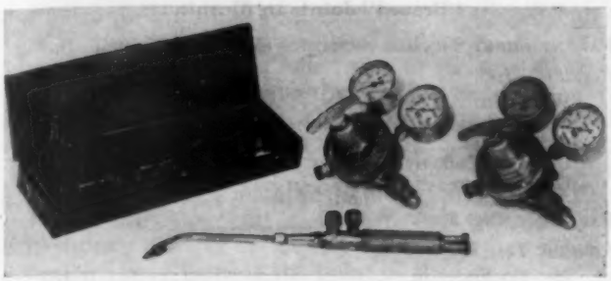


Fig. 10—High-Pressure Type Equipment

use for certain classes of work, however, due to their copper content. For example, food regulations prohibit the use of an aluminum alloy containing copper for any vessels which are to contain food; also it would probably not be permissible to use a rod containing copper for very stringent corrosive conditions such as would be encountered in many countries abroad. There are available in America brazing rods of a silicon-copper-aluminum alloy, in which the copper content is not more than 5%. These rods have excellent flowing properties and they are undoubtedly very suitable for a large number of applications. It is conceivable, however, that their use might not be permitted, or desirable, under food regulations for containers or where corrosive conditions may be set up. The straight silicon type rod which falls into the L33 specification group does not suffer from these objections.

Flux

Borax base fluxes used for brazing metals other than aluminum are not suitable. A flux which will remove the oxide (alumina), and will melt at a temperature below the melting point of the rod, is essential for easy operation. The flux when heated to its liquid state must spread or flow smoothly and cleanly ahead of the molten filler metal. It is also necessary that the flux in its powder form must be completely mixed and in a state of fine division usually to pass at least a 200-mesh sieve (B.S.S. standard). Preferably it should be so fine that the majority of it is capable of passing a 325-mesh. A few aluminum fusion welding fluxes will be found suitable for brazing, but others have a melting point which is too high and they are also coarsely granular and quite unsuitable. A specially compounded flux for brazing having very

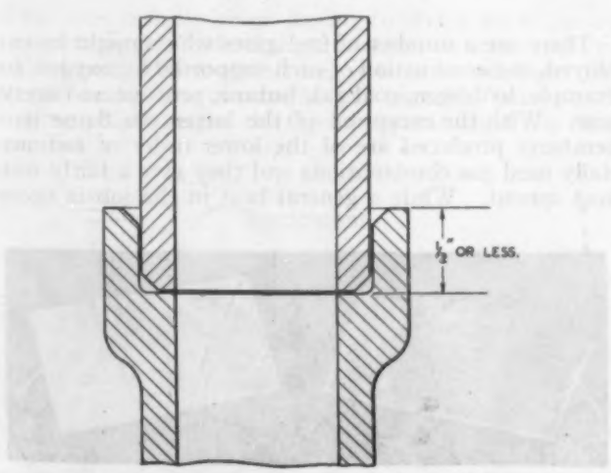


Fig. 11—Suggested Preparation for Socket Joint

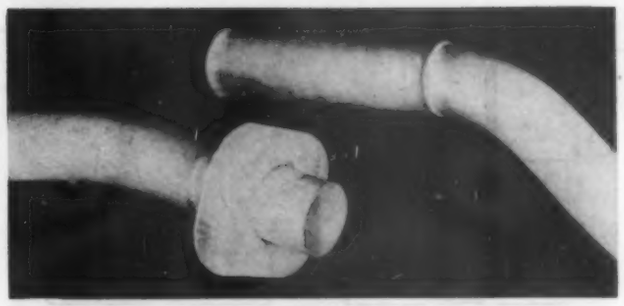


Fig. 12—Note "Bell Mouth" Joint of Rear Tube

small percentages of a heavy metal inclusion is claimed to be particularly effective. It flows cleanly and rapidly ahead of the filler metal and does undoubtedly assist the brazing operation. It "wets" and cleans both the joint and brazing metal causing the latter to spread quickly and smoothly and to penetrate completely.

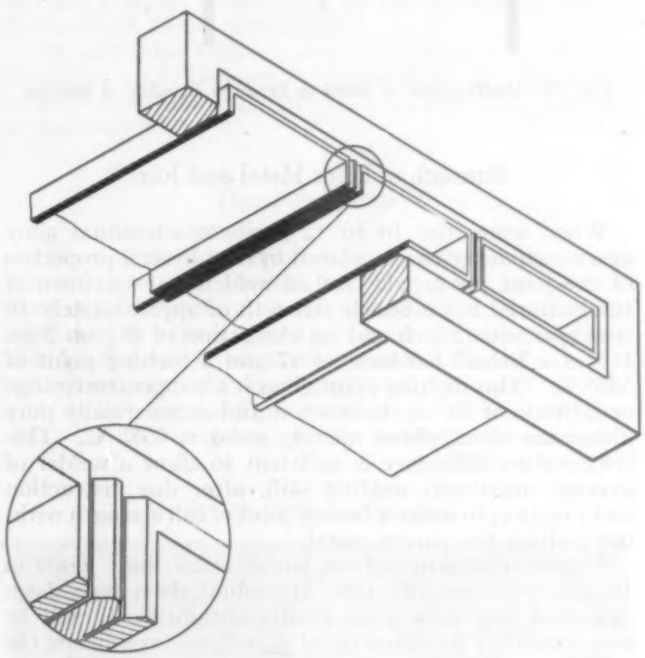


Fig. 13—Preparation for Brazing from the Face of the Joint

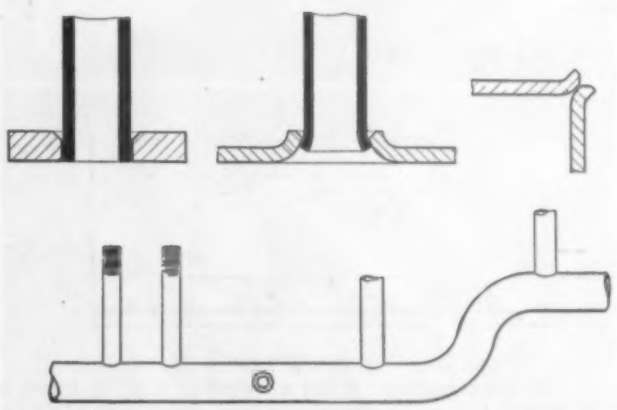


Fig. 14—Examples of Joints Suitable for Brazing

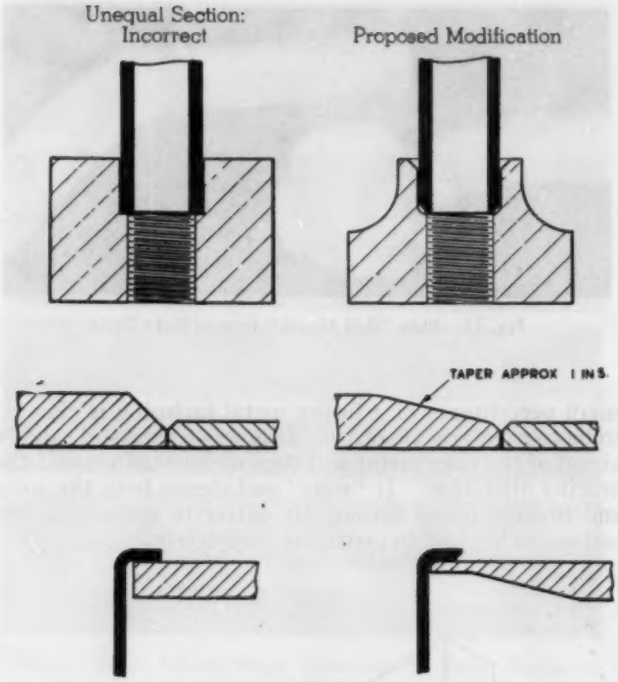


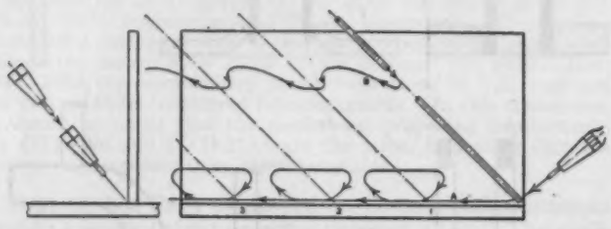
Fig. 15—Modification of Joints to Produce Equality of Section

Strength of Filler Metal and Joint

When using the 10 to 12% silicon-aluminum alloy every confidence can be placed in the physical properties of the joint produced. An all-weld metal specimen of this material has a tensile strength of approximately 10 tons† per square inch and an elongation of 6% on 2 in. It has a Brinell hardness of 47 and a melting point of 585° C. This melting point gives it a temperature range or latitude of 73° C. between it and commercially pure aluminum sheet whose melting point is 658° C. This temperature difference is sufficient to allow a welder of average aluminum welding skill, after due instruction and practice, to make a brazed joint of full strength without melting the parent metal.

Tensile specimens of both lap and plain butt joints in 16 gage commercially pure aluminum sheet have been examined and very good results obtained. It will be seen that they have fractured at a figure well below the parent metal in its hardened condition as would be expected. It can be said, however, that the strength of both lap and butt joints are equal to, or possibly greater than, the strength of material in its fully annealed condition.

† British Long Ton = 2240 lb.



Operator's View

A, blowpipe movement; *B*, rod movement; *1*, *2*, *3*, Points of application of rod.

Fig. 16—Blowpipe and Rod Manipulation

"Brazed" Joints in Aluminum

PARENT SHEET TENSILE SPECIMEN (Material as supplied), Fig. 4

Result of Test:

Width, in.	1.22
Thickness, in.	0.062
Area, sq. in.	0.0756
Ultimate load, tons	0.95
Ultimate stress tons per sq. in.	12.56

LAP JOINT, Fig. 5

Result of Test:

Lap thickness, in.	0.132
Sheet width, in.	1.318
Sheet thickness, in.	0.062
Sheet area, sq. in.	0.0817
Lap width, in.	1.318
Lap area, sq. in.	0.174
Ultimate load, tons	0.55
Ultimate stress, tons per sq. in.	6.73
Position of fracture	In sheet 1¼ in. from center line of lap

LAP JOINT, Fig. 6

Result of Test:

Sheet width, in.	1.025
Sheet thickness, in.	0.063
Sheet area, sq. in.	0.0646
Lap width, in.	1.025
Lap thickness, in.	0.132
Lap area, sq. in.	0.1353
Ultimate load, tons	0.40
Ultimate stress tons per sq. in.	6.20
Position of fracture	In sheet 3¾ in. from center line of lap

BUTT JOINT, Fig. 7

Result of Test:

Width, in.	1.2
Thickness, in.	0.065
Area, sq. in.	0.078
Ultimate stress tons per sq. in.	5.77
Elongation %:	
on 1 in.	44
on 2 in.	36
on 4 in.	22
Position of fracture	In sheet, ½ in. from center line of joint

Micrographs:

Fig. 8. Showing "fillet" of joint metal connecting the lapped aluminum sheets. Magnification by 50.

Fig. 9. Showing "penetrated" joint metal connecting the lapped aluminum sheets. Magnification by 100.

The joint metal is "Silotectic" aluminum silicon alloy.

The microstructure of the joint metal consists of primary aluminum rich dendrites in a matrix of aluminum-silicon-eutectic. The bond between the rolled aluminum sheets and the joint metal is perfect.

Fuel Gas Employed

There are a number of fuel gases which might be employed, the combustion of each supported by oxygen, for example, hydrogen, coal gas, butane, propane and acetylene. With the exception of the latter the flame temperatures produced are of the lower order of commercially used gas combinations and they give a fairly wide heat spread. While a general heat in the job is neces-

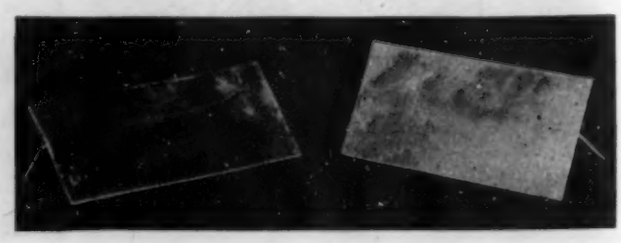


Fig. 17—Note Underside Disturbance of Left-Hand Sample

sary for rapid brazing, these flames add to the difficulty of preventing edge melting or local collapse. Also, it is difficult visually to adjust the flame to the neutral condition. For these reasons the oxyacetylene flame is much to be preferred. The greater temperature and localized heat concentration enables the operator to generally preheat the part at or about the joint fairly rapidly and then by blowpipe manipulation to apply the addition heat to brazing temperature close to and alongside the joint without danger of melting small edges or projections which may be near the point of the brazing operation.

A further advantage of the oxyacetylene flame is that the operator can concentrate his attention upon the flow

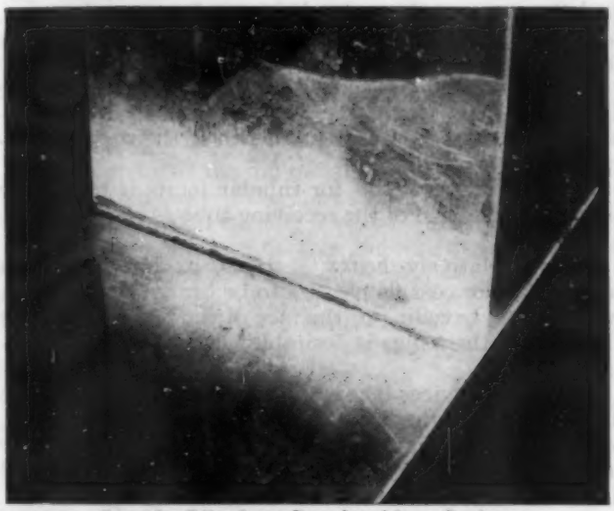


Fig. 18—Fillet Joint Completed by a Student

Fig. 19—Brazed Spouts and Handles of Domestic Ware

of the filler metal without having to divide his attention by watching this and other parts of the structure, which, with a greater heat spread might tend to collapse. Especially is this true of some of the "brazable" alloys with melting points nearer the fluid temperature of the filler material.

Equipment

Standard welding equipment is used, but care must be exercised in adjusting the flame to strictly neutral conditions. For this reason it is desirable to use a high-pressure blowpipe and two stage type regulators as shown in Fig. 10. This ensures that steady and stable flame conditions are maintained. The power of the blowpipe used is usually a little less than would be used to fusion weld the same part. For very small assemblies a nozzle one size smaller than for fusion welding working at standard gas pressures will be found to be more effective than the larger nozzle with gas pressures reduced. This is because a flame at standard gas pressures has a better "driving" effect causing the fluid filler rod to drive or run ahead more readily.

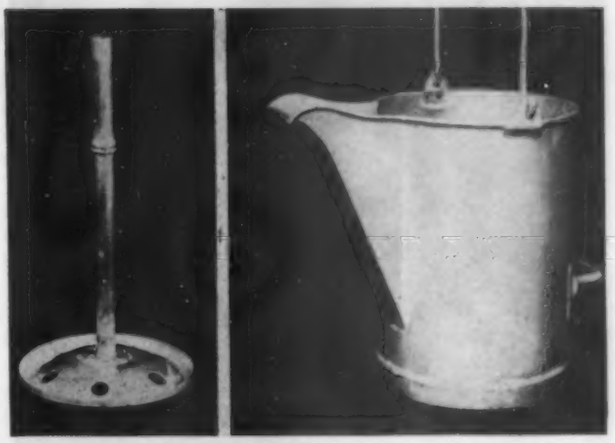


Fig. 20 (Left)—Fabricated Coffee Percolator Tube
Fig. 21 (Right)—An Ideal Type of Construction for the Application of the Brazing Method

For large assemblies, or greater mass of metal, the nozzle as would be used for fusion welding is necessary, however, to compensate for greater heat loss by radiation or conduction.

Flame Adjustment

The flame must be adjusted to the strictly neutral condition as previously stated, and due care must be exercised with this operation. It is not sufficient to set the regulators at recommended pressures, light the flame, and then make loose or rapid movements with the blowpipe control valves to obtain a sharply defined inner blue cone.

After lighting the acetylene flame the blowpipe oxygen valve should be opened slowly until the inner cone is

Fig. 22—Fabricated Brackets

Fig. 23—Further Fabrication Examples

Fig. 24—Special Wireless Receiving Part Fabricated from Tube with Disks and Threaded Stub Brazed Into Position

well defined, but with a slight haze or mistiness around its point.

This haze should be as small as possible; if the cone appears "ragged" it is burning with an excess of acetylene which is definitely incorrect for a neutral flame or for brazing aluminum.

Adjusting the flame as described is desirable because as the nozzle becomes hot the flame tends to revert to slightly oxidizing conditions, so losing the mistiness. This condition is then a visual telltale, or indication to the operator of what is happening, and he should immediately rectify or readjust his flame when the haze disappears.

Preparation

Press fits and very close tolerances are not recommended since diffusion is apt to render the molten filler metal rather less fluid during brazing, resulting in incomplete penetration. Slight clearances are advisable to enable complete penetration of brazing metal and flux to be obtained. The amount of clearance should be determined by trial, but as a general rule it may be said that the wider the lap, the greater the amount of clearance necessary. In the case of socket joints it may be advisable to put a slight taper, to a depth equal to that of the socket, on the inside of the outside tube.

Adequate support for long seams is necessary in order to prevent sagging.

For positioning of parts, the use of self-locking joints, rivets or spot welds is recommended in preference to jigs, which suffer from the disadvantage of chemical attack by the molten flux, the possibility of becoming alloyed with the brazing alloy, and the difference in thermal expansion between the aluminum workpiece and jig material.

Commercially pure aluminum sheet can be brazed without mechanical removal of the normal surface shine or oxide film provided the sheet is new and clean and the surface is free from grease or other foreign contamination. Degreasing can be carried out by a quick dip in an organic solvent such as carbon tetrachloride or trichlorethylene. The brazing operation should be completed as soon after degreasing as is practicable. The line of joint or surface area which will receive the brazing metal should not be handled unnecessarily between the degreasing and the brazing operation.

Aluminum alloys, however, must have the surface oxide removed mechanically by brisk scratching with a piece of steel wool, wire brush or file. Strict attention to this detail is necessary if a satisfactory, smooth and attractive looking joint is to be obtained.

Material edges must be smooth and all burrs and projections removed by filing. A sheared edge which is usually burred or uneven needs this little attention.

Sleeved type joints should have the short inserted portion restricted as much as possible—preferably it should be less than $1/2$ in. The outer sleeve well or socket can be left square on the end. It is an advantage, however, to bevel this end to 45° for half its thickness, to provide a trough or recess to receive the filler metal; also to treat the inserted end likewise to assist penetration (see Fig. 11). It is sometimes recommended that a wedge-shaped recess of 5–10° for full depth of the socket be arranged.

An alternative to this for tubular joints is to slightly bell mouth the end of the receiving tube as shown in Fig. 12.

Where relatively heavy sections, as for example a heavy plate or cast flange, are to be brazed on to a light walled tube, bevelling of the face of the flange as well as the back of the flange is desirable, although not a necessity.

In some instances it may not be possible to apply the filler metal from the back in the conventional manner as, for example, in Fig. 13. This shows three rectangular tubes close together with a thin spacer between each and fitted into a single rectangular hole in the flange.

The most convenient method is to chamfer the face of the flange and braze all joints from this side.

There are of course many and various types of joints which may be encountered, and Fig. 14 shows diagrammatically further examples which lend themselves to satisfactory brazing operations.

Summarizing the question of preparation, therefore, it may be said that cleanliness and good fitting joints are the first requirements. A light bevel or chamfer to 45° to provide a recess or "lead" for the filler metal is always desirable. Wherever possible abutting or contacting surfaces should be brought to equal thickness or near equality of section.

Examples are shown in Fig. 15. This latter preparation considerably aids the brazing operation and reduces the possibility of contractional stress or cracking.

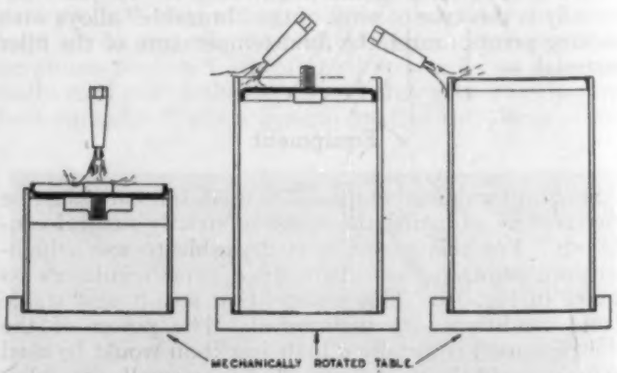


Fig. 25—Schematic Arrangement for Semiautomatic Brazing of Part Shown in Previous Figure

Flame and Rod Manipulation

After the part is assembled and set up for brazing it should be generally preheated with the envelope of the flame, the inner blue cone being held about 2 in. clear of the metal surface. The blowpipe and rod are held at approximately the conventional angles as for fusion welding. The end of the rod is then heated and dipped into the flux tin to which a small amount of flux will adhere.

The "tuft" of flux is then touched down upon the surface of the joint to check the temperature. At the correct temperature the flux will begin to flow smoothly and rapidly forward along the joint. Then and then only should a small amount of filler metal be added and the rod withdrawn.

It is most important that no filler rod is melted off until the flux can be seen flowing freely, induced by the heat of the work. In this connection, however, it should be noted that long periods of heating are apt to render the flux less active, thus making the brazing operation move difficult.

At the moment the rod metal begins to flow, the blowpipe is moved toward the joint until the inner cone is almost at the normal welding position. At the same time, and in conjunction with this movement, it is moved rapidly forward with a flicking action, drawn away and brought back to the original distance, but at a position opposite that to which the molten metal has traveled for the movement to be repeated (see Fig. 16).

Capillary attraction together with the driving action of the flame moved close to the joint surface causes the molten metal to run forward along the joint.

This cycle is repeated as the brazing proceeds, except that additional flux is not required for short seams or joints. Extra flux should not be applied to larger seams before the previous application has become ineffective. Too much flux masks the operation and is in no way beneficial. The procedure of brazing is one in which the ability of the operator plays a considerable part and no doubt many operators will, after preliminary training, develop a variation of the sequence described to suit themselves or any peculiarity of the work they are engaged upon.

During preliminary training and practice they should concentrate upon making a joint with only sufficient temperature to cause the brazing medium to flow smoothly. Excessive temperature—although it may cause the filler metal to become more agile—should be avoided. Progress can be checked by examining the underside of a standing fillet joint. A good brazed joint should not affect the underside of the metal. If the oxide film is crinkled or shows signs of disturbance, the temperature has been unnecessarily high, as is shown on the left-hand side of Fig. 17.

A student's work and progress is shown in Fig. 18 which is a standing fillet in 16-gage commercial aluminum sheet, completed after a few hours' practice. He was already an experienced fusion welding operator when instructed in brazing procedure.

Flux Removal

Due to the corrosive nature of the flux all residue must be completely removed after brazing to prevent possible corrosion and to improve the appearance of the finished part. Dipping the part into water while it is still hot removes the greater amount of surplus flux, as the fluxes used are soluble in water, but this is insufficient as a complete treatment.

A simple method is to scrub the part with a stiff bristle brush during immersion in hot soapy water and then to rinse in clear water.

A more positive method is to dip it into a solution of 5 to 10% nitric acid and lightly scrub afterwards, washing in clear, preferably running water. The latter is necessary to remove all traces of acid, which, if left, would itself contaminate the completed work.

It is sometimes recommended as an alternative to this to immerse the part in water and boil for 20 min. and then clear rinse. This method has the advantage that it facilitates drying.

Occasionally, it may be found that for some class of work the removal of every vestige of flux is considered of utmost importance and the recommendation may be as follows: preliminary dipping in 5% sodium hydroxide at 150° F. followed by a warm water rinse, then a longer dip of 1 to 2 min. in cold 50% nitric acid.

This appears to the writer to be unnecessarily stringent for general-purpose work, and in any case this treatment should not be used on machined parts of fine tolerances, due to some slight metal loss from sodium hydroxide attack.

Fig. 26—Light-Alloy Angle Section Joint with Gusset Plate Stiffener

Where a bath type immersion is employed it must be remembered that flux residues quickly contaminate the solution. Such residues, therefore, will contaminate the work as a whole unless draining or systematic changing of the solution is provided for.

Some Applications and Procedure

There are many applications, both actual and potential, in the production of small sheet metal and combination sheet casting, tube and machined parts or the fabrication of various subassemblies in the electrical, air-

Fig. 27—An Etched Sectional View of the Previous Figure

craft, wireless, domestic utensil or light engineering fields.

Examples are tubular and sheet aluminum wave receiving gear for wireless or radiolocation units, screens, stands and casings for wireless and other electrical sets, small box container corners and lap seams, indication disks and tabs for aircraft and other tubing where weight saving is of prime importance, and fixing of cast spouts, handles, percolator tubes, etc., in domestic ware, as shown in Figs. 19 and 20.

In this latter field may be included food containers of all descriptions; Fig. 21 shows such a utensil which has been fusion welded. This would be ideal for brazing. Postwar development of food and delivery van bodies of all descriptions in light alloys is another field of application.

In light engineering and sheet metal working the potential applications are infinite and varied.

Some examples of tubular and bracket constructions are shown in Fig. 22. An interesting feature is the small tube shown on the right of Fig. 23. This is an experimental section to screw into the end of a flexible metallic tube. It was made up by winding a pure aluminum wire of $^{3}/_{32}$ in. diam. around a $1^{1}/_{2}$-in. bore aluminum tube. Brazing the wire to the tube was accomplished as the wire was wrapped with the tube slowly rotated.

Another tubular job eminently suitable for brazing is shown in Fig. 24. This involves the jointing of a disk about $^{1}/_{2}$ in. from the end into a 3-in. diameter tube. The disk also has a collared and threaded part brazed into it prior to final assembly, the brazing of this having been on the underside as it appears in the photograph.

The brazing of both the stub to the disk and the disk into the tube is semiautomatic. Small turntables mechanically driven with a friction drive rotate the parts under a fixed flame. The female operator has only to flux the joint and feed in sufficient brazing rod when the flux becomes fluid. A schematic arrangement is shown in Fig. 25.

Where inequality of the joint is encountered the flame is played mainly on to the thicker section. This principle also is shown diagrammatically in the same figure where blanks of 20-gage material are being brazed into 16 gage tubes.

Light alloy angle section construction will figure largely in postwar development and a gusset-plated joint is shown in Fig. 26. This joint after brazing develops considerable strength and is well suited to the process. However it must be completely sealed around all contacting surfaces and edges. Penetration of filler metal across the width of the angle section from the fillet side of the joint alone cannot be guaranteed. Due to this there may be flux entrapped with possible consequent corrosion from the unsealed edges to the joint.

The angle section is of the aluminum-manganese-magnesium type and the gusset plate is a clad alloy to DTD-390. The writer does not consider that clad material is the most suitable. It is considered that the gusset plate should be of similar material specification to the section, or of commercially used pure aluminum. An etched sectional view of the heel of this joint is shown in Fig. 27 and although disturbance of the cladding did not occur at the fillet joint of the top angle section, some breakdown of the aluminum covering and diffusion of silicon and copper occurred at the lower fillet joint.

The next view in Fig. 28 shows a "mock up" of part of a joint in certain wireless equipment, the piece on the left-hand side having been brazed and that on the right, fusion welded. The brazed joint is smooth with penetrated metal right through the turned-down flanged joint, and with the upstanding edge of the rear plate retained and no disturbance of the material surface opposite the fillet joint. In the case of the fusion weld there was crinkling and some melting of the surface of the rear sheet and the upstanding edge was "caught" here and there.

The time factor which is always important showed greatly to the advantage of the brazed joint, brazing being completed in considerably less than one quarter of the time of fusion welding.

Future Development

The writer believes that as the ease, speed and overall advantage of brazing of light alloys becomes more generally appreciated the demand for its use will constantly increase. It has been approved for various classes of work and some British Air Ministry drawings now specify "10–12% silicon aluminum brazing."

The introduction of light alloys into the postwar housing schemes will stimulate jointing methods such as brazing for window frames, louvres, decorative panels and other accessories.

The recent Aluminum Exhibition in London also shows the trend of uses of these materials and one could see

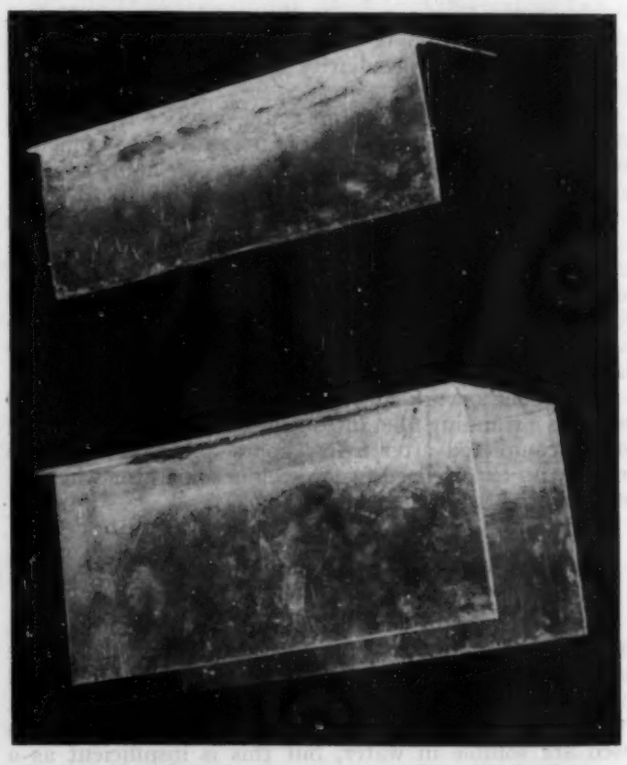


Fig. 28—Mock Joints for Comparison of a Brazed and a Fusion-Welded Joint for Certain Wireless Parts

household ware of every type, sinks, draining boards, wheelbarrows, garden seats and many other applications too numerous to mention, all of which have joints to be made at some stage of their manufacture.

Much laboratory and practical experimental work is still to be done. There are many alloys for which present fluxes do not appear suitable or are not sufficiently active.

Acknowledgments

The writer gratefully acknowledges the permission and facilities granted by the British Oxygen Co. Ltd. to prepare this article, also the assistance and helpful comments from Britain's Service and Research Departments, and friends of the Northern Aluminium Co. Ltd.

Soft-Soldering Nonferrous Metals

By G. H. Bohn*

THE terms "soft-soldering" and "hard-soldering" are sometimes confused by operators, who may use them interchangeably or use the term "soldering." Soft-soldering is the process of joining metals without melting the base metal, using an alloy (solder) fusible at temperatures below 700° F.—below the red heat range. In hard-soldering (also called silver-soldering or silver-brazing) the solder fuses at temperatures above 1200° F. (red heat).

The use of 60–40 solder (60% tin–40% lead) or 50–50 solder (50% tin–50% lead) makes it possible for even the novice to do acceptable soft-soldering. The high tin content of these solders makes them easy to work with. With solders in which the maximum tin content is limited to 30%, however, even old hands at soldering encounter difficulties.

Blowpipes for Soldering

Two types of blowpipes or torches are available for use in soft-soldering nonferrous alloys: (1) an oxyacetylene welding blowpipe, (2) an air-acetylene torch with single hose connection.

A typical blowpipe of the first type is shown in action in Fig. 1. The tip sizes for soldering will vary from No. 6 or 7 to No. 15, depending on the thickness and type of the metal being soldered. Oxygen is used in combination with city gas or with natural gas instead of with acetylene, because the oxyacetylene flame is too hot for soft-soldering.

* The Linde Air Products Company, Tonawanda, New York.

Fig. 1—Soldering a White-Metal Automobile Grill Using a Light-Duty Oxyacetylene Blowpipe

Fig. 2—The Air-Acetylene Torch Being Used for Soldering Joints in a Metal Roof

The second type uses acetylene and atmospheric air. This is the type favored by electricians, plumbers and sheet metal-workers because they can easily carry the small portable cylinders of acetylene anywhere on the job. Figure 2 shows the portability of this type of torch outfit where it must be carried up a ladder. In Fig. 3, the outfit has been brought conveniently right to the work in a cafeteria. This torch has both open-flame tips and soldering iron tips. When fitted with large soldering irons, it is used for thin metals such as No. 20 B.w.g. (0.035 in.) or lighter. The soldering iron is shown in use in Fig. 4.

Melting and Flowing Temperatures of Solders

When a piece of soft solder is heated by any of the means described above, it starts to melt at a definite

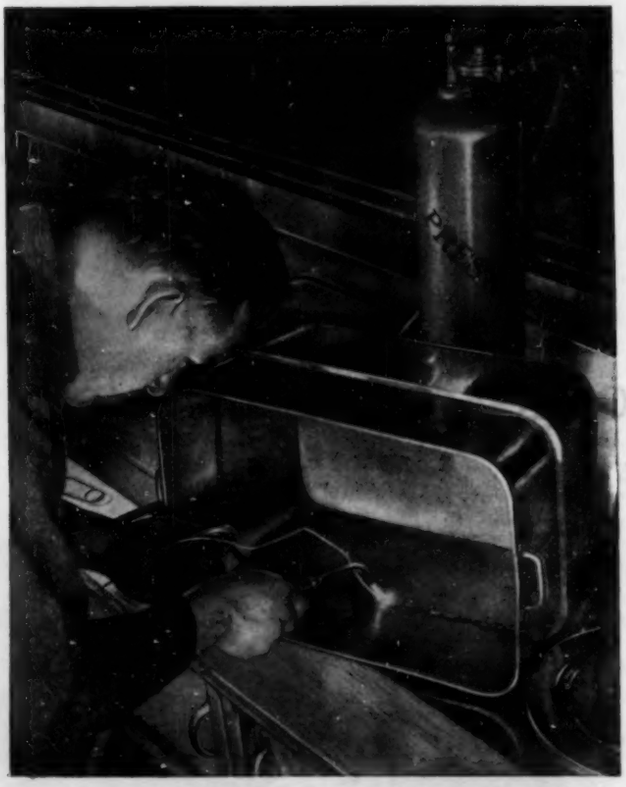


Fig. 3—The Convenience of an Air-Acetylene Torch Outfit Is Demonstrated in This View of an Operator Soldering a Seam in a Monel Metal Food Container

temperature, depending on the type of solder. As additional heat is applied, the temperature increases, and more and more solder melts until it is all melted. Let us call the first temperature the *melting point* and the second temperature the *flowing point*. The latter temperature is important because the metal must be heated to a temperature higher than the flowing temperature, or the solder will not flow.

As a soft-soldered joint cools, the solder solidifies fully at the melting point. Until the joint has cooled to a temperature below the melting point, no strain can be applied to the joint, since solder has no strength, while it is partially solidified. Between the flowing and melting points is the so-called plastic range, in which there is a mixture of solid and liquid solder.

A few solders melt and flow at the same temperature.

Table 1—Temperature Characteristics of Commonly Used Solders

Solder Composition	Melting Point, ° F.	Flowing Point, ° F.	Plastic Range, ° F.
Tin, 60% Lead, 40%	361	372	11
Tin, 50% Lead, 50%	361	421	60
Tin, 40% Lead, 60%	361	453	92
Tin, 30% Lead, 70%	361	486	125
Lead, 95% Silver, 5%	579	689	110
Lead, 97.5% Silver, 2.5%	579	579	0 (eutectic)
Tin, 28% Lead, 70% Antimony, 2%	361	484	123

These are called "eutectic" solders and are suitable for making bead joints, but are not suitable for running into lap joints. It helps to know the melting and flowing points and the plastic range when changing from a solder of known composition to a substitute solder. Table 1 gives these data for solder compositions commonly used.

Let us see how Table 1 will help a coppersmith who changes from one type of solder to another. Let us assume he was using 50–50 solder, but now is to use 30–70 solder. (It is usual practice to state the tin content first in a tin-lead solder.) Both solders melt at the same temperature, but the 30–70 solder must be heated 65° higher to make it flow, and in cooling must pass through a 125° range instead of a 60° range before becoming entirely solid.

So far, only straight tin-lead solders have been considered, but other elements can be added to soft-solder-mixtures. For solders containing 40% or less tin, the addition of antimony, up to 6% but not more than 7% of the tin content, seems desirable for use on nonferrous metals. It is generally not desirable to add bismuth because it has low strength and is difficult to flux. The solder mixture of 95% lead and 5% silver is worth considering. It is a very satisfactory solder for use on threaded pipe fittings of Everdur 1010, whereas the tin-lead solders are not satisfactory.

Fluxes for Soft-Soldering

Fluxes play an important part in the soldering operation. Fluxes accomplish this in two ways—(1) by shielding the cleaned metal from the air and thus retarding the formation of an oxide film, and (2) by removing any oxide that might be on the surface when the solder is applied.

Table 2 gives the compositions of various commonly used fluxes with their characteristics and suggested uses. Small quantities of these fluxes can usually be obtained in powder, paste or liquid form, or as cores in the hollow-wire form of solder.

Some old-time copper shops still make their own flux.

Fig. 4—An Air-Acetylene Torch with a Soldering Iron Tip Is Used for Soft-Soldering a Corner Lap Joint of Cold-Rolled Copper. Note the Glass Container of Flux and the Solder in Wire Form

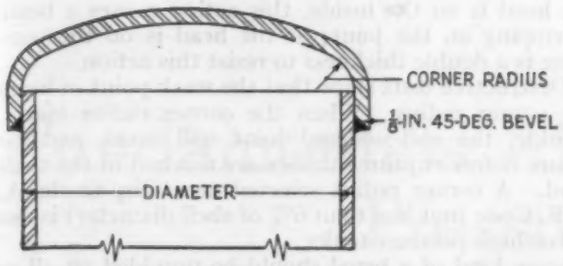


Fig. 5—Joint Design for a Nonferrous Head to Be Soft-Soldered to a Container Shell. Note that the Head Is on the Outside of the Shell

The one most commonly used is made by the addition of an excess of zinc to hydrochloric (muriatic) acid to form zinc chloride. The strength of such fluxes is unpredictable, but if this method is used, it is better to dissolve an ounce of zinc chloride for each four ounces of water. A better method is to purchase a prepared flux from flux specialists.

Some flux manufacturers add "wetting agents" to their fluxes, having determined the amount to be added by experimental work. "Wetting agents" are penetrants that cause the solder film to thin out and cover a larger area. Fluxes with "wetting agents" are not necessary for 50–50 or 60–40 solders, but they are not detrimental. However, it is advisable to use fluxes with "wetting agents" for the lower-tin solders. This is particularly necessary for long joints on copper or for all joints on brasses and bronzes.

Principles of Successful Soldering

Low-tin solders require a more careful soldering technique than the prewar 50–50 or 60–40 solders. The tinsmith or coppersmith will also find that soldering with the low-tin solders is more difficult on the brass alloys than on plain copper. The following principles for successful soldering are of importance in using low-tin solders:

Table 2—Characteristics and Uses of Various Fluxes

Flux	Characteristics	Use
Rosin or rosin in alcohol	Noncorrosive	Electrical
Zinc chloride mixtures	Corrosive	Nonferrous
Zinc chloride plus hydrofluoric mixture	Corrosive	Brasses and bronzes containing aluminum, silver and manganese

1. Remove all dirt and grease from the surface to be soldered, before fluxing. This can best be done by wiping the surface with a cloth dipped in an inorganic cleaner or detergent or by dipping the piece itself in the solution. Finally clean the surface with fine steel wool until it is bright and free from oxide. Careful cleaning is particularly necessary with the low-tin solders.

2. Follow immediately with a flux. The low-tin solders alloy more slowly, and so stronger flux solutions are necessary. The use of fluxes with "wetting agents" helps materially.

3. Make sure the surfaces fit and contact each other as perfectly as possible. If bevels are not provided in the design of lapped joints, file a bevel or bell out the lapping edges. This will act as a feeder channel. The matter of joint design is discussed in more detail later. Tight joints are particularly important with low-tin solders.

4. Heat the *metal*—not the solder—above the flowing temperature of the solder, remembering that the low-tin solders require higher metal temperatures (see Table 1). Remember that just filling the feeder channel with solder is not enough. Heat the lapped joint until the solder drops disappear from the bevel and continue to apply solder until the joint is filled.

5. Use a flux while soldering, applying it by dipping the solder in the flux from time to time.

6. Do not touch or disturb the soldered joint until it has cooled below the melting point and is therefore fully set. After the temperature has dropped below the melting point (see Table 1), wet cloths can be used to decrease the time normally required to cool the joint to room temperature.

7. The stronger the flux, the more corrosive it is—so be sure to clean off all traces of flux from the completed joint. This is best done by using water.

8. If a very smooth job is desired, finish the joint by removing the high spots with a medium file.

If the joint has a sufficiently small diameter to be heated all over, such as in water-service tubing, there should be no trouble with low-tin solders if the above procedure is used. However, on large-diameter joints, pretinning both sides of the joint, after proper cleaning and fluxing, is an additional help.

The same procedure applies to the high lead-silver solders, except that a temperature about 250° higher than that for 50–50 solder is required to make the solder flow. The high lead-silver solders can be used where higher temperatures of application are not a handicap, such as for Everdur. However, because of the higher temperature required, the same flux that is used for 50–50 solder cannot be used for the lead-silver solders. Special fluxes for this purpose are available, and flux manufacturers should be consulted.

Types of Flames

When the first type of blowpipe is used with an oxy-city gas flame, the correct flame is soft, not sharp. The sharp flame is too concentrated; the softer flame acts like a brush and is much better for soft-soldering.

When the second type of torch is used with the air-acetylene flame, the correct flame should show a bright, sharply defined inner cone and a pale-blue outer flame. A yellow flame shows that the acetylene pressure is inadequate, that the needle valve is not opened sufficiently, or that the soldering iron is clogged.

Design of Soft-Soldered Joints

Complete design data would require more space than is available here, but a few fundamentals will be discussed.

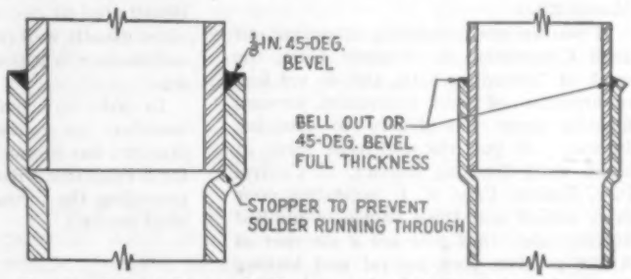


Fig. 6—A Joint Design Is Shown at the Left for Soft-Soldering Tubing or Shells Having a Wall Thickness Greater Than 1/8 In. (Right) A Joint Design for Soft Soldering Thin-Walled Tubing or Shells

Two excellent publications on the strength of soft-soldered joints, BMS-58 and BMS-83, can be obtained for ten cents each from the U. S. Dept. of Commerce, National Bureau of Standards, Washington, D. C.

In BMS-58, it is stated that long-time tests indicate that 235 psi. is the maximum allowable stress permitted. for sustained loading at 85° F. This publication also shows that the allowable stress decreases rapidly as the temperature increases. The strength of soft-soldered joints depends to a great extent on the thickness of the solder film—the thinner this film, the higher the strength. The highest strength is obtained when the solder film is 0.003 to 0.005 in. thick. One of the best examples of this is the use of A.S.T.M.-B88 water-service tubing with copper, forged brass or cast brass fittings. Even for copper, this thinness of film is more essential for the lower-tin solders than for the 50–50 solders.

Experiments have shown that a joint can be designed as just explained and still fail because the test or working stress in the shell or tube is more than the yield point of the metal. On copper, for example, stresses of more than 10,000 psi. cause the metal to stretch, and joint failures are likely to occur whether the joint is long or short. Most of the nonferrous metals have low yield points, and for soft-soldered joints it is advisable to use stresses less than those permitted in Table U-3 Revised of the A.S.-M.E. Unfired Pressure Vessel Code for Welded Vessels.

In fabricating a tank or container of nonferrous metal, on which the head is to be soft-soldered, the joint should be designed with the head lap on the outside, as shown in Fig. 5. When pressure is applied, the head tends to form a hemisphere, thus decreasing the diameter. If the head is on the inside, this action causes a bending or ripping on the joint; if the head is on the outside there is a double thickness to resist this action.

Destructive tests show that the weak point in heads is the corner radius. When the corner radius starts to wrinkle, the soft-soldered joint will break and cause failure before rupture stresses are reached in the shell or head. A corner radius selected according to the A.S.-M.E. Code (not less than 6% of shell diameter) is essential on high-pressure tanks.

Some kind of a bevel should be provided on all soft-soldered lap joints, as shown in Fig. 6. These designs not only aid in filling the joint but also eliminate the wasteful and unsightly overflow of solder on the outside.

Testing Joints

When first making experimental joints with low-tin solders, the joint should be cut into strips 1 or 2 in. wide for test purposes. Tear the strip apart by bending one part back away from the other. If the joint bends more than 90° and examination of the broken joint shows the solder has taken hold 100%, the correct procedure was used. If the joint breaks without any bending, and examination shows spots where the solder did not flow, check the procedure used. It will usually be found that one or more of the steps outlined were not followed carefully. The most likely causes of failure are: (1) The joint was not thoroughly cleaned; (2) the metal was not heated above the melting point of the solder, or (3) the wrong flux was used.

ANNUAL MEETING

Undoubtedly the greatest Annual Meeting of the AMERICAN WELDING SOCIETY will be held in Atlantic City, during the National Metal Congress and Exposition, the week of November 17th. Headquarters for the SOCIETY will be at the Ambassador Hotel. All of the rooms in this hotel have already been taken. Overflow is being handled in adjoining hotels.

Some of the other hotels in the vicinity having rooms available are: Ritz Carlton, Dennis, Marlborough-Blenheim, Brighton, Mayflower, Jefferson and Madison. Location and rates of these hotels may be found on Housing Bureau circular sent you on March 22nd.

If you are contemplating attending our 1946 Convention in Atlantic City, the week of November 17th, and *do not have confirmation* of *hotel reservation*, forward filled-in form *immediately* to Housing Bureau. If you do not have form at hand, write Housing Bureau, 16 Central Pier, Atlantic City, N. J., indicating your first, second and third choice of unfilled hotels; also, that you are a member of A.W.S.; also, your arrival and leaving dates.

Twenty-four technical sessions have been provided in addition to the Adams Lecture and a special session devoted to the operation of Sections. These 24 sessions contain 87 technical papers.

Practically every phase of welding will be covered, including Weldability, Research, Railroad, Shipbuilding, Production, Storage Tanks, Pressure Vessels, Machinery, Resistance Welding, Electrodes, Structural, Cutting, Aircraft, Hard Facing, Pressure Welding and High Alloys.

This year, two issues of the JOURNAL will be set aside for the preprinting of Annual Meeting papers, namely, the October and November issues. This will provide members with an opportunity to see the papers in advance and prepare discussion. The amount of information distributed at one of these technical sessions usually well pays for the cost of time and money in attending the Anual Meeting.

In order to provide an opportunity for members to renew acquaintances, the SOCIETY has resumed the practice of holding a President's Reception on the Sunday preceding the formal opening of the technical sessions.

METAL CONGRESS

The 28th annual National Metal Congress and Exposition will be held in Atlantic City's Municipal Auditorium for five days beginning November 18th, according to an announcement made by W. H. Eisenman, managing director of the event.

Meeting jointly during the N.M.C.E. will be the American Society for Metals. The Iron and Steel Division and the Institute of Metals Division of the American Institute of Minining and Metallurgical Engineers, The AMERICAN WELDING SOCIETY and the American Industrial Radium and X-Ray Society.

According to Mr. Eisenman, floor plan for the regular 1946 Exposition at Atlantic City have been sent to organizations participating in the 1945 event which was held in Cleveland earlier this year.

The holding of the National Metal Congress and Exposition in Atlantic City marks the first time in five years that the event has been held in the East. It is anticipated that approximately 70% of the 1946 N.M.C.E. attendance will be from the eastern section of the country.

On the basis of previous attendance figures for N.M.C.E. meetings in Atlantic City, it is estimated that more than 25,000 executives, engineers and production men will visit the Exposition and attend technical sessions of the five societies meeting during the five-day period.

Fundamentals Affecting the Bond in Pressure Welds

By Leslie Fine,* Charles H. Maak† and Anthony R. Ozanich*

Introduction

DISCUSSIONS which were published in the past concerning oxyacetylene pressure welding tended to develop largely around the mechanical details of its industrial applications, and around strength evaluations based on physical testing data. Metallographic studies by other investigators contributed little to the knowledge of pressure welding because they were limited by conventional etches in what they could observe in welds. In one case, however, an unconventional etch based upon research[1] by one of the authors was employed and reported[2] by the Battelle Memorial Institute workers in metallographic studies of pressure welds. The mechanism of bonding was usually touched upon lightly with the exception of the treatment given the subject by A. B. Kinzel.[3]

The pressure-weld application in which the authors are chiefly concerned is in aircraft landing gear. This field is one requiring minimum weight, and welds of maximum physical properties and reliability. These conditions impose unusual burdens on the welds. In the initial stages of work on pressure welds, metallographic study showed that etches usually used, such as nital or picral, were of little value since microstructure appeared identical both in welds possessing very inferior properties and in those which were satisfactory. This accounts for the fact that in almost all cases, photomicrographs heretofore published of conventionally etched pressure welds have appeared identical with base metal, no weld line at all being visible. The inability to detect a weld line led investigators to the erroneous conclusion that the weld plane had been completely eliminated, and that all pressure welds so appearing were of high quality. Figure 1 illustrates such a pressure weld of inferior quality etched in nital. As can be seen the location of the weld is in no way apparent.

One of the authors has developed a metallographic etch ("alkaline chromate etch") which reveals the presence of dissolved oxygen or iron oxide in steel. Information concerning it has been published recently.[1] Its use in the microstudy of pressure welds has indicated the presence of dissolved oxygen‡ in welds of substandard strength. A general discussion of the subject by the authors has been published recently.[4] By way of illustration, the identical area shown in Fig. 1 is presented in Fig. 2, after repolishing and etching with alkaline chromate solution. The location of the weld plane and its relatively high oxygen content are apparent.

Before continuing further, a brief description of the pressure-weld process and a clarification of some of the terms which will be employed are presented. Oxyacetylene pressure welding is accomplished by butting together under pressure two pieces of metal and heating the juncture uniformly with a burner until the desired amount of upsetting takes place in the area of the joint. The press employed is usually hydraulic, and is built with necessary controls such as hydraulic and gas-pressure regulators and also a device to shut off the burner and hydraulic pressure when the welding cycle is complete. The parts to be welded usually are prepared with flat weld faces and in most cases with a chamfer around the outer edge or around both the inner and outer edges to control the plastic flow of the metal at the joint in the desired manner during welding. Shapes best suited to pressure welding are those with simple sections such as solid rounds or tubing, although more complex cross sections can be welded. All welds discussed in this paper are made from tubular sections heated by means of an external torch only. Use of only the external torch allows freedom in structural design that is mandatory in aircraft landing gear, but complicates welding due to the presence of air inside the tubular sections. The absence of such complication is readily recognized in the welding of solid bar stock.

A clarification of some of the pressure-welding terms to be employed in this paper follow: "Weld face" refers to the contacting ends of pieces to be welded. "Weld plane" is used in discussing the generally flat area in which bonding takes place. This area is regarded as being composed of a "metal-to-metal interface" where atomic bonding establishes the weld; of submicroscopic voids or empty spaces which interrupt this metal-to-metal interface; and in very poor welds, oxide inclusions as well. "Bonding" is the over-all establishment of the attractive forces at the weld plane. "Upsetting" refers to the plastic deformation of the metal at the weld due to the application of heat and pressure, while "gather" refers to the amount of the shortening which parts undergo when they are upset. The phenomenon of "surface energy" herein presented refers to surface free energy, of which surface tension is the mathematical concept, and does not refer to total surface energy which consists of surface free energy plus the heat involved in the changing of surface area at an interface.

Voids Present at the Weld Plane

A rough means of determining the general character of pressure welds is available in the hammer fracture test which consists of clamping in a vise a weld coupon notched in the plane of welding and hitting the projecting half with a hammer. Notching in this fashion forces fracturing to occur in the plane of the weld or closely adjacent to it, depending upon the quality of the weld or

* Metallurgical Laboratory, Menasco Manufacturing Co., Burbank, Calif.
† Formerly with Metallurgical Laboratory, Menasco Manufacturing Company, Burbank, California. Presently associated with Pressure Weld Consulting Company, Burbank, California.

‡ It is not definitely known whether oxygen as the element or as an oxide goes into solid solution in steel. "Dissolved oxygen" will hereafter be used for simplicity of terminology.

upon the condition of heat treatment. The value of the test is not in estimating the impact strength of the weld, except in a crude way, but rather in determining whether the bond is strong enough to pull out grains or fracture through grains on either side of the plane of welding. The test, though crude, is nevertheless quite useful in making comparisons between the impact strength of the bond versus the impact strength of the base metal. Pressure welds made with medium carbon low-alloy steels, except in the case of very poor welds, always show a rough crystalline fracture in the as-welded condition. Even high-quality pressure welds, however, when quenched from the usual hardening temperature and tempered to approximately Rockwell "C" 40 to 43 usually produce a fine textured noncrystalline flat impact fracture through the weld plane when notched as described above. (This type of fracture is shown later in Fig. 11.) Since quite often fracturing takes place off the weld plane despite this notching, it appears that a very high-quality pressure weld can closely approach base metal strength in this type of impact resistance.

This anomalous type of flat fracture apparent in quenched and tempered weld specimens indicated at an early stage of the investigation that even though welds were satisfactory and free of any dissolved oxygen as revealed by the alkaline chromate etch, the weld plane still differed from the base metal due to the presence of some unknown condition. It was with the object of identifying this unknown that another metallographic etch—the phosphoric acid electrolytic etch—was developed.* It produces at the weld plane a line of etching pits otherwise undetectable, the intensity of attack varying directly with the quality of the weld. A pressure weld so etched is shown in Fig. 8. The theory of its action is that submicroscopic voids indicating discontinuity in bonding are present at the weld plane and are revealed by the etching reaction which increases their size so that they can be resolved microscopically. It is felt that these voids may be essentially empty spaces or may possibly contain nitrogen. They vary in quantity with the quality of the weld. It is believed that action takes place preferentially along the edges of voids because of the tendency for current density to increase along edges and cause more rapid solution at those points.

* This etch was developed by L. Fine.

Fig. 1—Nital Etch of a Pressure Weld Made From NE 8740 and Which Appears Satisfactory. The Weld Plane, Though Not Visible, Runs Lengthwise. 200 ×

Fig. 2—Same Area Shown in Fig. 1 After Repolishing and Etching with Alkaline Chromate. The Location of the Weld Plane and Its High Oxygen Content Are Apparent. 200 ×

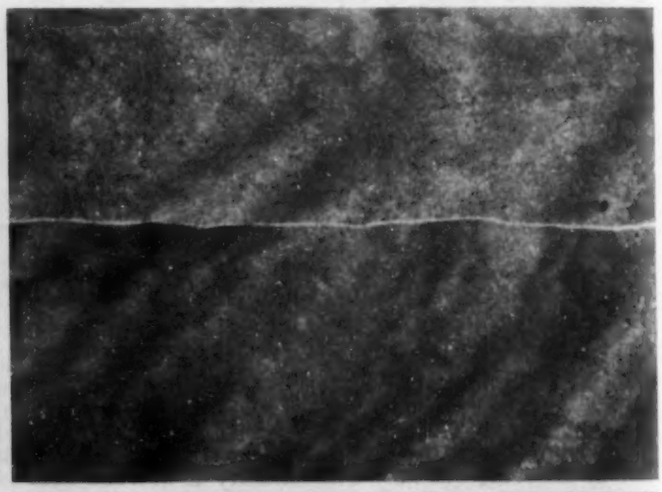


Fig. 3—Phosphoric Acid Electrolytic Etch of a Pressure Weld Containing Spotty Areas of Dissolved Oxygen. This Spottiness Was Induced by Employing an Extremely Rough Cutter-Ground Finish on Weld Faces. The Diamond Indentor of a Microhardness Tester Was Drawn Over the Area Shown for Identification. 80 ×

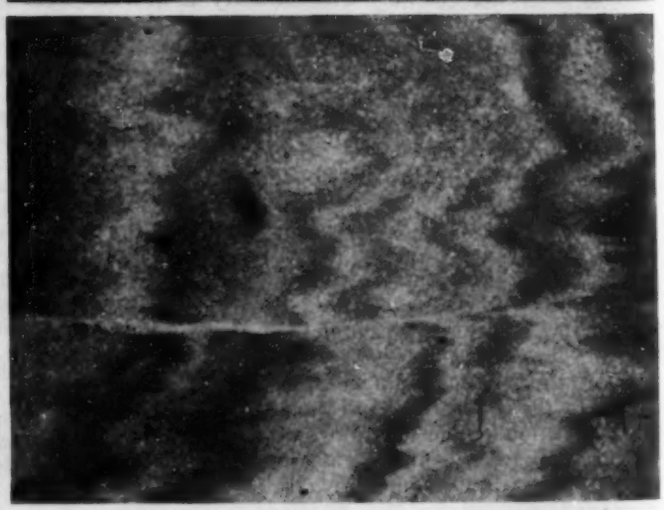


Fig. 4—Alkaline Chromate Etch of the Identical Area Shown in Fig. 3 After Repolishing. The Most Vigorous Attack Is Seen to Have Occurred Where a Concentration of Oxygen Existed. Only a Remnant of the Microhardness Tester Indentation Remains. 80 ×

Fig. 5—Alkaline Chromate Etch of an NE 8739 Pressure Weld Deliberately Made to Possess a High Oxygen Content. As-Welded Condition. 200 ×

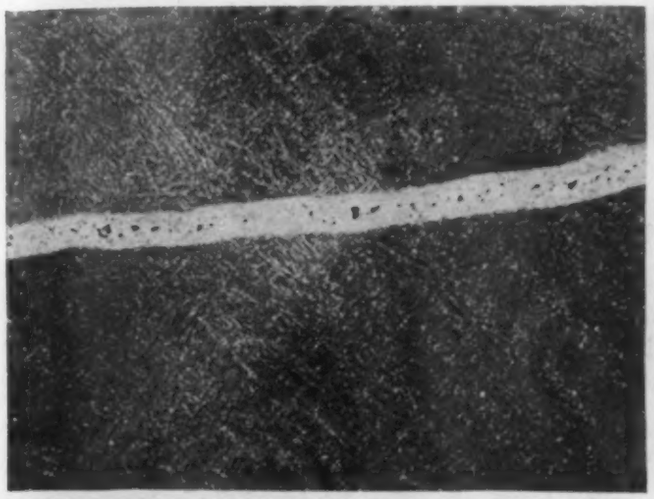


Fig. 6—Alkaline Chromate Etch of the Same Pressure Weld Shown in Fig. 5, but After a 3-Hr. Soak at 2300° F. The Oxides Have Partially Dissolved and Oxygen Is Diffusing Away from the Weld Plane. 200 ×

Fig. 7—Alkaline Chromate Etch of the Same Pressure Weld Shown in Fig. 5, but After 8-Hr. Soak at 2300° F. Solution of Oxides and Diffusion of Oxygen Away from the Weld Plane Are Almost Complete. 200 ×

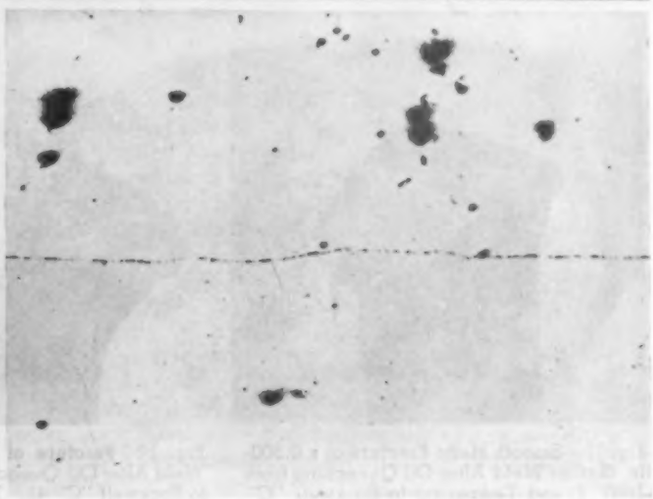


Fig. 8—Phosphoric Acid Electrolytic Etch of an NE 8739 Weld Considered Satisfactory. The Weld Plane Is Attacked in the Usual Fashion. 80 ×

As would be expected, segregations and inclusions are also vigorously attacked as shown by the strings of dots and lines running in the direction of rolling. The size of the etching pits that have been observed in an average weld after a 15-min. etching period ranges from approximately 0.00001 in. diameter (barely perceptible with a 1.25 numerical aperture 78X oil immersion objective) to approximately 0.0002 in. diameter. A plot of pit diameter versus etching time indicates that the rate of size increase is a decreasing function. Pits may not appear until after continued etching for several minutes. Their appearance then is sudden and the rate of size increase soon tapers off to a straight line function. This observation would indicate that voids are initially extremely small.

The above discussion concerns the etching attack on high-quality pressure welds, but applies fundamentally to all pressure welds. Poor quality welds can be made which contain oxide inclusions. On such welds the visible evidence of the phosphoric acid electrolytic attack is a summation of the attack on voids plus that on the oxides. It is advisable to mention here that experimental evidence does not exclude the possibility of the fundamental pitting attack being due to the presence at the weld plane of submicroscopic particles insoluble in steel. Such particles, just as oxides, would also produce pitting. In view of the fact that there is no evidence indicating the presence of such submicroscopic insolubles, and that much experimental evidence points to the presence of voids, the latter theory is held by the authors.

Phosphoric acid electrolytic etching is carried out in commercial 85% orthophosphoric acid using austenitic stainless steel as a cathode and the specimen as the anode. A current density of about 1 amp. per square inch at a potential of 4 v. produces a satisfactory etch in approximately 15 min. Spacing between the cathode and the specimen is about 1 in. Etching for weld comparison is best carried out by briquetting in bakelite, drilling through the bakelite to contact the embedded specimen, pressing in a copper or brass conductor, and then immersing the unit in the solution. The conductor, however, should be kept above the level of the solution. In the case of low-alloy medium carbon steels, the specimens can best be examined when they are as-quenched or quenched and tempered to approximately Rockwell "C" 38 to 45. After etching, the specimen should be rinsed immediately in water and then in alcohol. When using this method of etching for determining relative char-

upon the condition of heat treatment. The value of the test is not in estimating the impact strength of the weld, except in a crude way, but rather in determining whether the bond is strong enough to pull out grains or fracture through grains on either side of the plane of welding. The test, though crude, is nevertheless quite useful in making comparisons between the impact strength of the bond versus the impact strength of the base metal. Pressure welds made with medium carbon low-alloy steels, except in the case of very poor welds, always show a rough crystalline fracture in the as-welded condition. Even high-quality pressure welds, however, when quenched from the usual hardening temperature and tempered to approximately Rockwell "C" 40 to 43 usually produce a fine textured noncrystalline flat impact fracture through the weld plane when notched as described above. (This type of fracture is shown later in Fig. 11.) Since quite often fracturing takes place off the weld plane despite this notching, it appears that a very high-quality pressure weld can closely approach base metal strength in this type of impact resistance.

This anomalous type of flat fracture apparent in quenched and tempered weld specimens indicated at an early stage of the investigation that even though welds were satisfactory and free of any dissolved oxygen as revealed by the alkaline chromate etch, the weld plane still differed from the base metal due to the presence of some unknown condition. It was with the object of identifying this unknown that another metallographic etch—the phosphoric acid electrolytic etch—was developed.* It produces at the weld plane a line of etching pits otherwise undetectable, the intensity of attack varying directly with the quality of the weld. A pressure weld so etched is shown in Fig. 8. The theory of its action is that submicroscopic voids indicating discontinuity in bonding are present at the weld plane and are revealed by the etching reaction which increases their size so that they can be resolved microscopically. It is felt that these voids may be essentially empty spaces or may possibly contain nitrogen. They vary in quantity with the quality of the weld. It is believed that action takes place preferentially along the edges of voids because of the tendency for current density to increase along edges and cause more rapid solution at those points.

* This etch was developed by L. Fine.

Fig. 1—Nital Etch of a Pressure Weld Made From NE 8740 and Which Appears Satisfactory. The Weld Plane, Though Not Visible, Runs Lengthwise. 200 ×

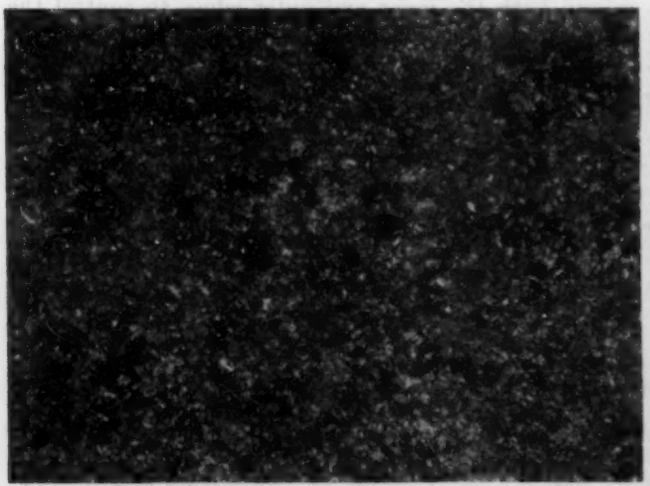
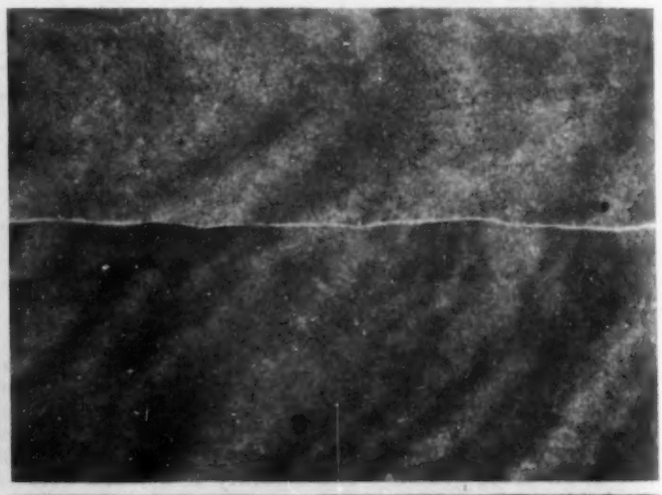


Fig. 2—Same Area Shown in Fig. 1 After Repolishing and Etching with Alkaline Chromate. The Location of the Weld Plane and Its High Oxygen Content Are Apparent. 200 ×



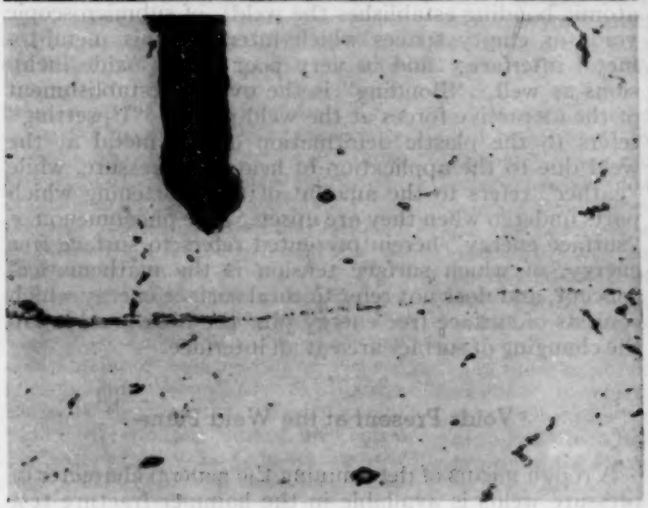


Fig. 3—Phosphoric Acid Electrolytic Etch of a Pressure Weld Containing Spotty Areas of Dissolved Oxygen. This Spottiness Was Induced by Employing an Extremely Rough Cutter-Ground Finish on Weld Faces. The Diamond Indentor of a Microhardness Tester Was Drawn Over the Area Shown for Identification. 80 ×

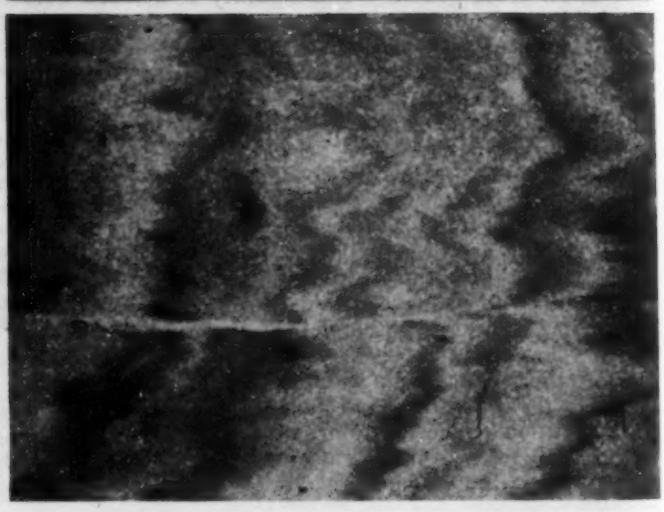


Fig. 4—Alkaline Chromate Etch of the Identical Area Shown in Fig. 3 After Repolishing. The Most Vigorous Attack Is Seen to Have Occurred Where a Concentration of Oxygen Existed. Only a Remnant of the Microhardness Tester Indentation Remains. 80 ×

Fig. 5—Alkaline Chromate Etch of an NE 8739 Pressure Weld Deliberately Made to Possess a High Oxygen Content. As-Welded Condition. 200 ×

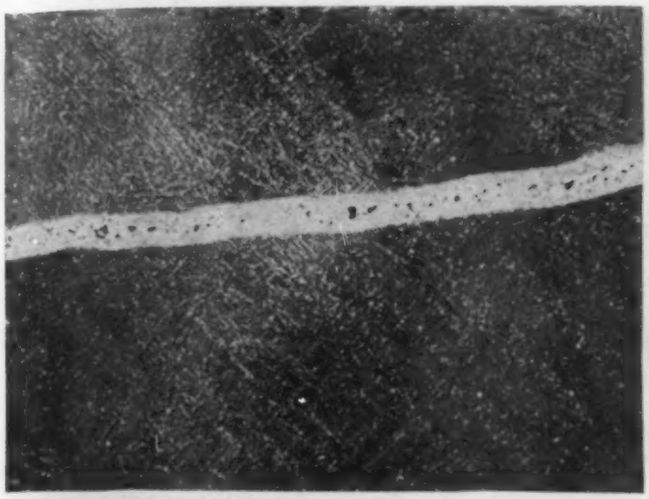


Fig. 6—Alkaline Chromate Etch of the Same Pressure Weld Shown in Fig. 5, but After a 3-Hr. Soak at 2300° F. The Oxides Have Partially Dissolved and Oxygen Is Diffusing Away from the Weld Plane. 200 ×

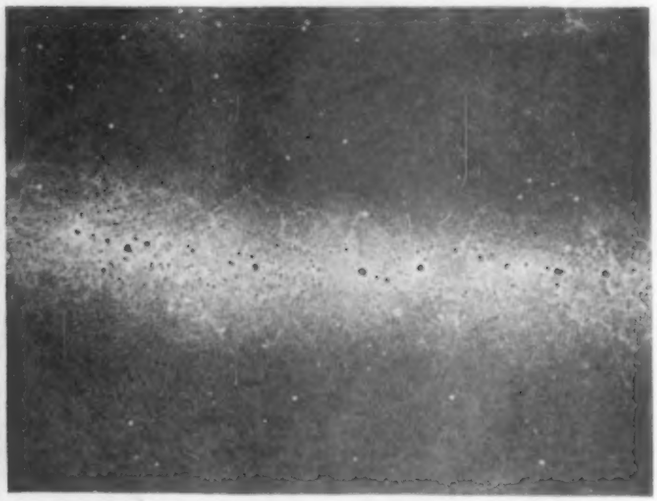


Fig. 7—Alkaline Chromate Etch of the Same Pressure Weld Shown in Fig. 5, but After 8-Hr. Soak at 2300° F. Solution of Oxides and Diffusion of Oxygen Away from the Weld Plane Are Almost Complete. 200 ×

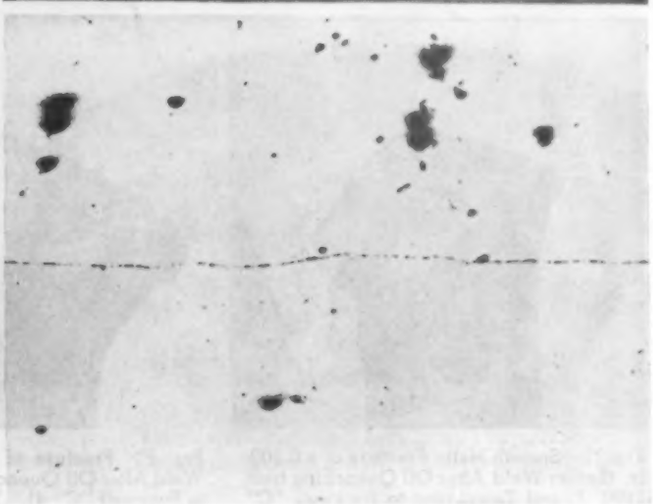


Fig. 8—Phosphoric Acid Electrolytic Etch of an NE 8739 Weld Considered Satisfactory. The Weld Plane Is Attacked in the Usual Fashion. 80 ×

As would be expected, segregations and inclusions are also vigorously attacked as shown by the strings of dots and lines running in the direction of rolling. The size of the etching pits that have been observed in an average weld after a 15-min. etching period ranges from approximately 0.00001 in. diameter (barely perceptible with a 1.25 numerical aperture 78X oil immersion objective) to approximately 0.0002 in. diameter. A plot of pit diameter versus etching time indicates that the rate of size increase is a decreasing function. Pits may not appear until after continued etching for several minutes. Their appearance then is sudden and the rate of size increase soon tapers off to a straight line function. This observation would indicate that voids are initially extremely small.

The above discussion concerns the etching attack on high-quality pressure welds, but applies fundamentally to all pressure welds. Poor quality welds can be made which contain oxide inclusions. On such welds the visible evidence of the phosphoric acid electrolytic attack is a summation of the attack on voids plus that on the oxides. It is advisable to mention here that experimental evidence does not exclude the possibility of the fundamental pitting attack being due to the presence at the weld plane of submicroscopic particles insoluble in steel. Such particles, just as oxides, would also produce pitting. In view of the fact that there is no evidence indicating the presence of such submicroscopic insolubles, and that much experimental evidence points to the presence of voids, the latter theory is held by the authors.

Phosphoric acid electrolytic etching is carried out in commercial 85% orthophosphoric acid using austenitic stainless steel as a cathode and the specimen as the anode. A current density of about 1 amp. per square inch at a potential of 4 v. produces a satisfactory etch in approximately 15 min. Spacing between the cathode and the specimen is about 1 in. Etching for weld comparison is best carried out by briquetting in bakelite, drilling through the bakelite to contact the embedded specimen, pressing in a copper or brass conductor, and then immersing the unit in the solution. The conductor, however, should be kept above the level of the solution. In the case of low-alloy medium carbon steels, the specimens can best be examined when they are as-quenched or quenched and tempered to approximately Rockwell "C" 38 to 45. After etching, the specimen should be rinsed immediately in water and then in alcohol. When using this method of etching for determining relative char-

Fig. 9—Phosphoric Acid Electrolytic Etch of the Same Weld as Shown in Fig. 8, but Following a 5-Hr. Hold at 2300° F. No Change Has Occurred in the Etching Attack. 80×

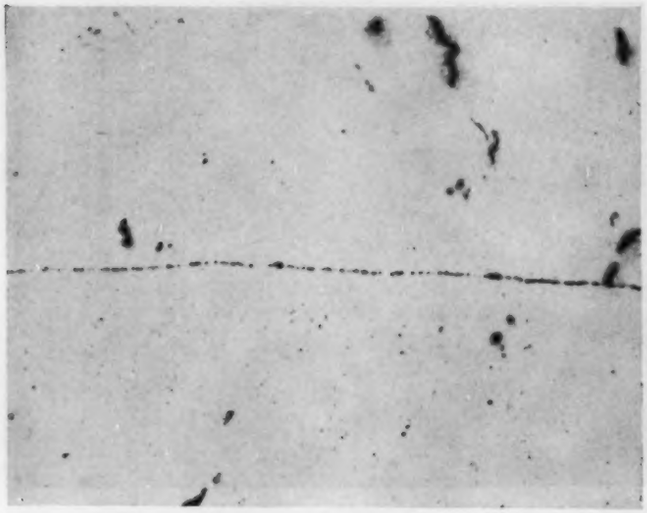
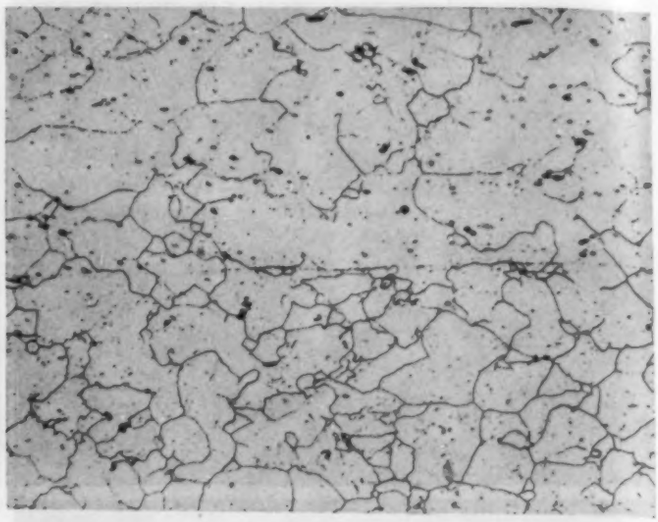


Fig. 10—Pressure Weld Made from 18-8 Austenitic Steel. It Can Be Seen That Crystallization Has Taken Place Across the Weld Plane, Which Is Delineated by Undiffused Inclusions. 80×



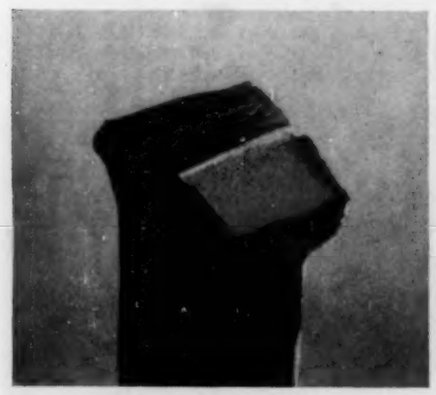


Fig. 11—Smooth Matte Fracture of a 0.300-In. Gather Weld After Oil Quenching from 1600° F. and Tempering to Rockwell "C" 41. 2½×

Fig. 12—Fracture of a 0.800-In. Gather Weld After Oil Quenching and Tempering to Rockwell "C" 41. The Smooth Fracture Becomes Rougher as the Center of the Wall Is Approached. 2½×

Fig. 13—Fracture of the 0.800-In. Gather Weld When Forced to Break in the Middle of the Wall. The Faces Are Rough and in the Parent Metal; a Slight Flat Area Is Visible at the Inner Portion of the Fracture. 2½×

acteristics in welds, the etching conditions must be held constant and the degree of resistance to attack at the weld plane used as a measure of quality.

As discussed in the article on pressure welding previously referred to,[4] welds having a concentration of dissolved oxygen at the weld plane as shown by the alkaline chromate etch exhibit inferior physical properties. In such welds the extent of attack by phosphoric acid corresponds very closely to the presence of dissolved oxygen and its relative amount. This correlation can be observed in Figs. 3 and 4. One might speculate, therefore, that electrolytic attack taking place most strongly where dissolved oxygen is present is due to the physical presence of the oxygen. However, there is evidence that dissolved oxygen is not the cause as is pointed out below.

Experiments previously reported[4] have shown that dissolved oxygen at the weld plane of a pressure weld diffuses when subjected to heating at high temperatures for long periods of time. Figures 5, 6 and 7 show specimens etched in alkaline chromate of an NE 8739 pressure weld deliberately made to possess a high oxygen content. The specimen in Fig. 5 is in the as-welded condition and those in Figs. 6 and 7 are shown after 3- and 8-hr. holds, respectively, at 2300° F., followed by an air cool. The diffusion of oxygen away from the weld plane is seen, there being almost no oxygen visible at the weld plane after the 8-hr. hold. This same high temperature was used on an NE 8739 pressure weld which was considered satisfactory and which was free of oxygen concentrations, appearing the same when etched with alkaline chromate as the section in Fig. 4 not showing the light etching zone. Figure 8 shows this weld electrolytically etched in phosphoric acid after quenching it in oil from 1600° F., and tempering it at 900° F. The usual attack along the weld plane is seen. Figure 9 shows the same pressure weld after soaking it 5 hr. at 2300° F., air cooling, and then quenching it from 1600° F. and tempering at 900° F. No difference can be seen in the electrolytic etching attack. This observation provides reasonable evidence that the phosphoric acid attack is due to a physical rather than to a chemical discontinuity formed by the presence of oxygen. This contention is held since an 8-hr. soaking at 2300° F. almost completely diffused a large amount of oxygen while a 5-hr. soak at the same temperature did not affect the weld's susceptibility to the phosphoric acid attack. These experiments indicate further that chemical action on other soluble contaminants is not the likely cause of the pitting attack because such contaminants would tend to diffuse away at least to some degree in the same manner as dissolved oxygen. Experi-

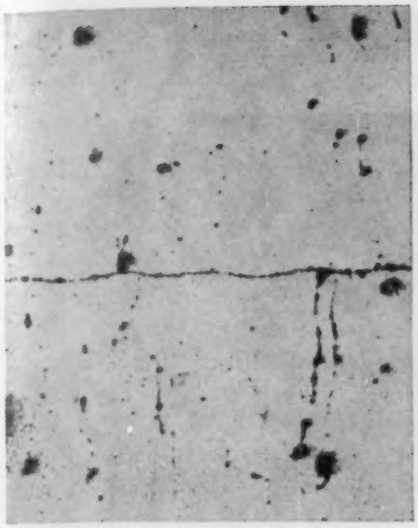


Fig. 14—Phosphoric Acid Electrolytic Etch of the 0.800-In. Gather Weld in an Area Corresponding to the Smooth Flat Fracture in Fig. 12. 80×

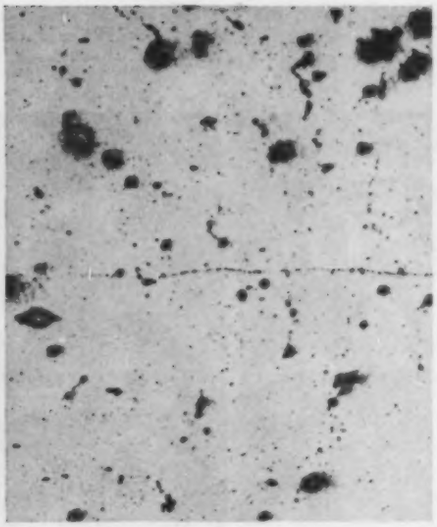


Fig. 15—Phosphoric Acid Electrolytic Etch of the 0.800-In. Gather Weld in an Area Corresponding to the Transition Fracture Zone in Fig. 12. 80×

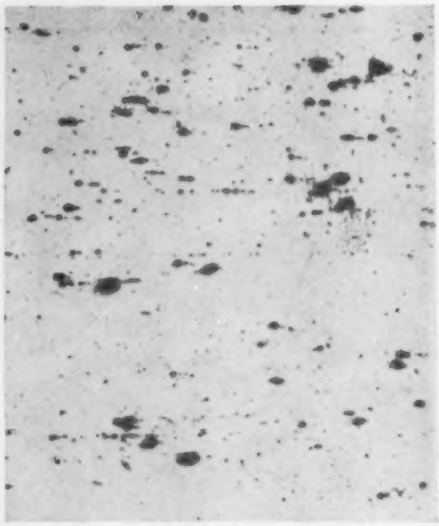


Fig. 16—Phosphoric Acid Electrolytic Etch of the 0.800-In. Gather Weld in an Area Corresponding to the Fracture in Fig. 13. 80×

mental evidence that a difference in the analysis of the steel on either side of the weld is not the cause of the attack is presented under "Plastic Deformation Due to Upsetting." It is there shown that the extent of attack can vary within a weld, and that increased gather alone can decrease the attack.

Types of fractures which may be encountered in different structures also seem to support the void theory. As has previously been mentioned and as is shown in Fig. 11, welds in low-alloy medium carbon steel which are oil quenched from 1600° F. and tempered to about Rockwell "C" 40–43 usually have smooth, flat, dull fractures. This fact is attributed to the micro notch-sensitivity of martensite or martensite tempered to within this hardness range. If the identical weld is quenched from 1600° F. into a bath at 750° F., held about 15 min., and then water quenched (resulting hardness being about Rockwell "C" 43) the fracture changes markedly. Instead of the weld break being flat, it tends to be rough and largely in the base metal. Where any part of the fracture may follow the weld plane it still tends to be quite rough. The partially bainitic structure produced by the above heat treatment most likely is less notch-sensitive than a tempered martensite and fractures in it thus do not tend to propagate from one void to another and produce the smooth fracture. In addition to the above observations, welds quenched from 2100° F. always show a rough fracture and indicate that the increased impact sensitivity of the base metal as a whole is sufficient to offset the effects of notch sensitivity which is due to void discontinuities.

Theoretical Aspects of Bonding

A concept heretofore held of the mechanism of bonding in pressure welding can be summarized as that of recrystallization and transformation increasing rates of diffusion, and thus promoting atom transfer and resultant crystallization across the weld plane. Consideration has not previously been given the mechanism of the formation of metal-to-metal interfaces. This formation necessarily must precede the establishment of atomic bonds inasmuch as such bonds cannot occur across voids which, although submicroscopic, may nevertheless be very much larger than the sphere of influence of the atoms at the weld plane. It has also been felt that despite a low degree of bonding, no actual separation exists in an oxyacetylene pressure weld.[3] In contradiction to this view, and on the basis of evidence supporting the void theory, the authors feel that actual separation does exist, since voids at the weld plane constitute actual separation.

Fundamentally, bonding in pressure welding is the cohesion of two metallic faces by atomic attraction. Theoretically, if two identical pieces of material of random grain orientation could be so faced off that variations from a geometric plane were of the order of normal atomic spacings, and if no contaminants were present when such faces were touched together, they should adhere with a bond comparable with the intergranular bond in any other section of the same material. Dissimilar materials equally treated should possess a bond equiva-

Fig. 17—NE 8630 Weld Made in Hydrogen by Heating 2 Hours at 2300° F. in Hydrogen. The Force of Gravity Supplied the Only Pressure Between Parts. 3×

Fig. 18—Nital Etch of a Section Through the Weld Shown in Fig. 17 and Made in Hydrogen. 80 ×

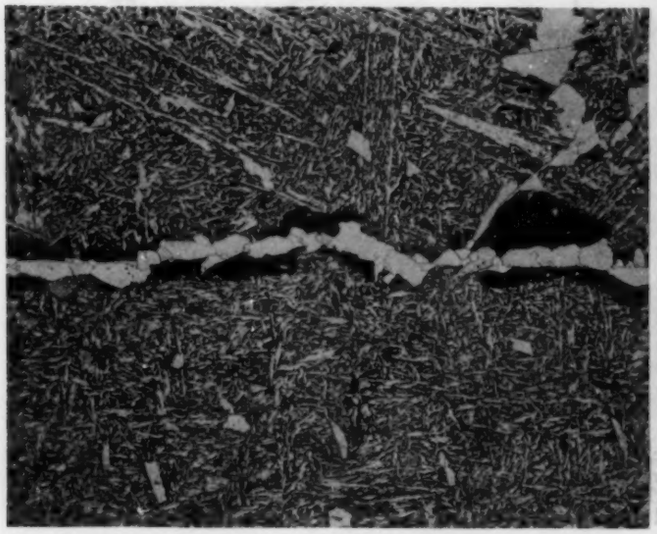


Fig. 19—Alkaline Chromate Etch of the Same Area Shown in Fig. 18. It Can Be Seen by Comparison with the Nital-Etched Section That Ferrite, Pearlite and the Widmanstätten Structure All Extend Across the Weld Line in Places. 80 ×

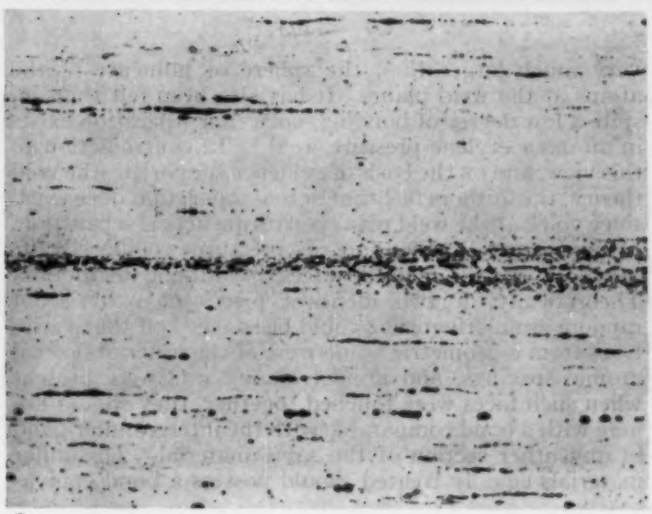


Fig. 20—Phosphoric Acid Electrolytic Etch of the Weld Made in Hydrogen. The Weld Was Quenched from 1800° F. Prior to Etching. 80 ×

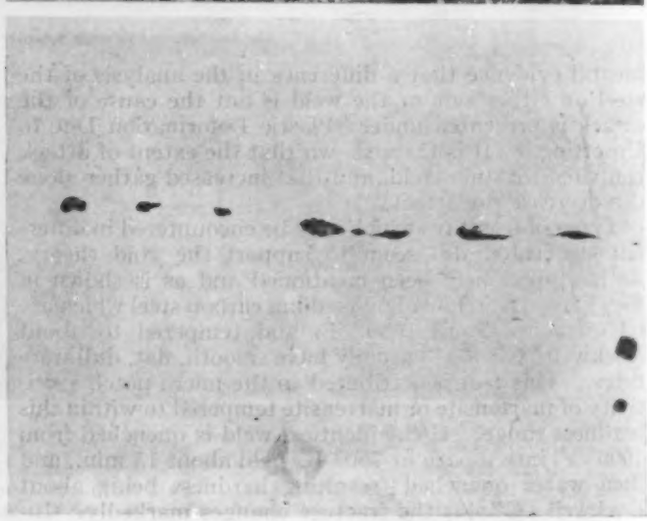
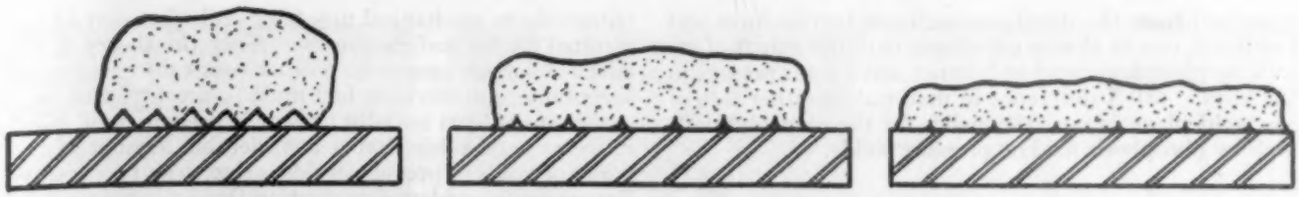


Fig. 21—As-Polished NE 8742 Weld Made in Hydrogen and with Gravity Supplying the Only Pressure. Face Roughness Was Controlled to Permit the Presence of Voids at the Weld Plane. 800 ×

lent to the summation of all the attracting forces between dissimilar atoms at the plane of juncture. Pressure, heat, recrystallization, and diffusion phenomena play no part in the above theoretical concept of bonding. Under actual welding conditions, however, they are valuable accessories to bringing about at the weld plane the basic requirements which are (1) intimate contact and (2) freedom from contamination. The effect of these accessories is summarized below and is discussed in greater detail later.

Pressure applied to parts during welding induces mechanical upsetting in the general area of the weld. The results of this deformation consist of the reduction of the size of voids present, the spreading of these voids apart, and the rupturing of the oxide film when it is too heavy to dissolve before such deformation takes place. Pressure also acts to seal out air and solids from the weld faces.

Heating of the weld plane during welding has a threefold effect. The first is that it decreases the plastic strength of the material, thus facilitating deformation due to surface energy forces and to mechanical upsetting. Secondly, atomic activity is increased by heating, thus increasing the rate of diffusion of contaminants. The mutual interchange of base metal atoms across the weld juncture, however, is regarded as of little importance inasmuch as such interchange can take place only after atomic linkage or bonding has already occurred. Such atom interchange therefore would have little effect on this prior bond. Thirdly, the importance of allotropic changes is believed to be restricted to the effacement of directional properties at the weld plane owing to lattice rearrangement and subsequent trans-interface crystallization. The lattice change due to transformation is not regarded as essential for the effacement of grain boundaries at the original weld plane, since it has been observed that an austenitic steel substantially devoid of transformation will crystallize across the weld plane in pressure welding. This occurrence is shown in Fig. 10. Evidence presented heretofore supporting the theory of the importance of transformation is regarded as inconclusive. Heat and pressure acting alone affect welding



Sketch 1—Illustrating Progressive Plastic Deformation of Serrations in Clay

as described above. In combination, they would tend to disperse contaminants by a mechanical spreading action in addition to some dispersion effected by atomic movement during resultant recrystallization from hot working.

Plastic Deformation Due to Upsetting

Commercially feasible machined finishes on the faces of parts to be pressure welded are very coarse when considered in the light of the per cent of total surface area in true contact at welding pressures. These pressures are approximately 3000–10,000 psi. of nominal cross-sectional area. True contact at these pressures consists merely of the touching of high points while the majority of the surface is in no contact whatsoever. This noncontacting surface is exposed to entrapped air. The most obvious means by which increased contact is established during welding is plastic deformation. Some plastic deformation occurs while the parts are cold, since instead of the 3000 to 10,000 psi. value, the pressure at the contacting points is actually well over the elastic limit of the material. This high local pressure is due to the fraction of the true cross-sectional area in contact. As heating begins and the temperature of the parts rises, the compressive strength of the material decreases, permitting progressively more deformation until the comclusion of the weld. With this continued interface formation, additional atomic bonding is made possible.

Plastic deformation at the weld surfaces during the welding cycle may be roughly illustrated by serrating one side of a piece of molding clay to simulate toolmarks on a face prepared for pressure welding, and then compressing the serrated side against a flat plate. The progression of plastic deformation at the serrated face is illustrated in Sketch 1. With a small amount of upsetting, a considerable reduction in size of the serrations occurs. When, however, upsetting is continued the rate of removal of serrations decreases so that even after extreme deformation, remnants of the original marks remain. The rate of filling in of the serrations thus appears to be a nonlinear function of upsetting. If two pieces of clay with roughened faces were butted together, the same principle would apply, but mutual filling-in would assist in removing irregularities.

Reasoning that the size of submicroscopic voids would vary in some inverse function of the amount of upsetting, welds made with extremely large upsets were investigated. Using NE 8630 tubing, $1^1/_2$ in. O.D. x $^1/_4$ in. wall welds were made under conditions which produce a satisfactory weld in this size, the normal gather being 0.300 in. Another weld was made under identical conditions and using the same material, but was gathered to 0.800 in. instead of 0.300 in. The torch was shut off after 0.300-in. gather was reached, and 0.500 in. additional gather then secured under increased pressure. Thus the amount of upsetting was the only important variable between the two welds. After oil quenching these welds from 1600° F. and tempering to Rockwell "C" 41, coupons were cut from them and hammer fractured in the manner previously described.

Figure 11 shows the flat-weld plane fracture which is typical of normal low-alloy medium carbon steel pressure welds after they are quenched from their usual austenitizing temperature and tempered to Rockwell "C" 40–43. Figure 12 shows a fracture through the 0.800-in. gather weld which represents roughly the area of the internal upset. The fracture progressively changes from a flat to a rough parent metal break as the middle portion of the weld is approached. Figure 13 shows the completely rough fracture which occurred in the middle portion of the weld. The sawcuts on several sides of the weld plane as shown in Fig. 13 were necessary in order to induce fracture in the weld plane or closely adjacent to it. Electrolytically etched specimens from both of these welds provided interesting data. Figures 14, 15 and 16 correspond to the flat, transitional and rough parent metal fractures, respectively. They represent portions of the weld starting from the area closest to the internal surface of the tube and progressing outwardly to the middle portion of the tube wall. It can clearly be seen that heavy etching attack corresponds to the flat fracture and the very light attack to the rough fracture. The difference in the etching attack between the center of the wall and the inner edge is due principally to progressively more upsetting or spreading action from the inside edge to the center portion of the wall. High-gather welds were made in other size tubing confirming the experimental results presented above. This weld not only correlates phosphoric acid attack with fracture characteristics, but also serves as evidence that a difference between material on either side of the weld plane does not cause the pitting attack by the phosphoric acid electrolytic etch. If this material difference were the cause, the amount of upsetting would not be very likely to alter the attack, nor would the attack vary within one weld. This argument is further verified by the fact that repeated welds made from material from the same bar of steel under identical welding conditions show no less resistance to the phosphoric electrolytic attack than welds made in the same manner but with different types of low-alloy medium carbon steels.

To further check into the effects of increasing upset, small specimens cut from welds using normal amount of gather were heated to within the forging range and reduced considerably in a direction normal to the weld plane by means of hammering. As would be expected on the basis of the foregoing discussion, electrolytic attack by phosphoric acid at the weld plane was substantially reduced. It is unlikely that heating during the process of reduction played a role in decreasing weld plane attack, as it has previously been demonstrated that no such effect was brought about by a 5-hr. soak at 2300° F. This latter fact is seen in Figs. 8 and 9. As in the previous case, this experiment also eliminates material difference as a cause for electrolytic attack by phosphoric acid.

On the basis of these observations it may be concluded that: (1) A large amount of upsetting at high temperature increases the area of intimate contact between two weld faces by reducing the size of the voids and by spreading them further apart. (2) The type of fracture in welds made from low-alloy medium carbon steel, oil

quenched from the usual austenitizing temperature and tempered, can be closely correlated with the extent of attack by phosphoric acid and, hence, with voids present in the weld. (3) A difference in material on either side of the weld plane is not responsible for the electrolytic attack by phosphoric acid on pressure welds.

Plastic Deformation Due to Surface Energy

The theory of surface energy was used by Wretblad and Wulff[5] to explain the phenomenon of increased area of bonding in powder compacts during sintering. They pointed out cases where, due to heating alone, pressed compacts were spontaneously subject to shrinkage and to consequent increased density, and that these changes were directly related to increases in bond strength. Their conclusion was that when the plastic strength of the material was sufficiently decreased by heating, surface energy was of a sufficient magnitude to cause the flow of material at contacting points into the voids.

Experimental evidence was presented in 1921 by Beilby[6] that surface energy forces may be of a sufficient magnitude to cause plastic flow in solids. Using Faraday's method of allowing specks of phosphorus to react on the surface of a dilute solution of gold chloride, he produced very thin gold films. These films were transferred to glass and heated to between 250° C. (482° F.) and 400° C.(752° F.), well below the melting point of gold. Observation of the film with a microscope showed clearly that heating had caused retraction of the film into globular or rounded forms. This change indicated that the elevated temperature employed had decreased the strength of the gold to a value less than would resist those stresses induced by surface energy, thus permitting plastic deformation to occur.

Desch[7] in 1923 also presented data concerning the flow of metals at subfusion temperatures. He discussed the effect on gold at subfusion temperatures. A solidified globule of gold was etched in aqua regia to reveal the sharp crystalline structure. Upon heating the globule at a temperature below the melting point, the angular figures were rounded. This deformation he attributed to surface energy.

It would be difficult to determine in a pressure weld what proportion of the filling of initial depressions is attributable to mechanical upsetting and what may be accounted for by surface energy. Since the theory of the effect of surface energy in powder compacts seems quite acceptable, and since the fact must be accepted that void spaces are at least initially present in pressure weld faces, it seems reasonable that a considerable amount of the filling of voids in pressure welds is due to surface energy. Experimental evidence supporting these general views is presented further on.

The theory of the manner in which surface energy changes the shape and reduces the size of voids is relatively simple and follows classical lines.[8] Its mathematical concept is that of "surface tension." Within the interior of a substance the forces acting on any atom are balanced due to the presence of other atoms around it. At the surface of the substance a condition of unbalance is present due to the absence beyond the surface of atomic forces balancing the inward attraction. Thus the direction of the summated forces on these surface atoms is inward. If the strength of the material is sufficiently high, no inward translation of surface atoms occurs. If the strength is sufficiently low, surface atoms move inward. As soon as any atom moves inward, the spacing of the surface atoms surrounding the one that moved becomes such as to increase their mutual attraction and cause movement toward each other. Whether this surface is a void interface or the surface of a solid, such movement affects the spacing of all other surface atoms and causes their movement in the direction of the displaced atom, thus reducing the original surface area until a limiting condition is reached. When the surface is that of a solid this limiting condition is a spherical shape; the limiting condition for a void is both a spherical shape and minimum size.

As the size of a void becomes infinitely small and its radius of curvature approaches zero, the surface energy also approaches zero because the atoms at the void interface approach a position of being surrounded by the solid on all sides. It can therefore be argued that if the surface energy per unit area of void interface decreases as the void becomes infinitely small, a condition of equilibrium must be reached in void size when the surface energy is no longer great enough to overcome the plastic strength of the solid to cause further reduction in void size. A void having an elongated, or, for simplicity of argument, an elliptical cross section would tend

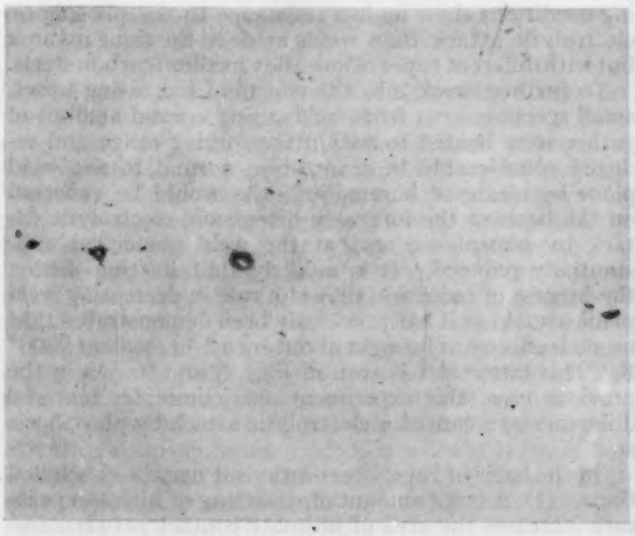


Fig. 22—Weld Shown in Fig. 21 After Heating 5 Hr. at 2300° F. Voids Present Are Rounded and Smaller Than Those Existing Before Heating. Condition Shown Is As-Polished. 1000×

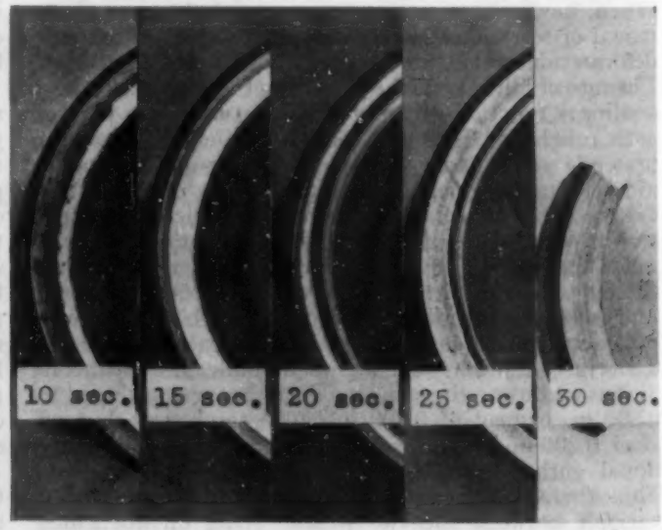
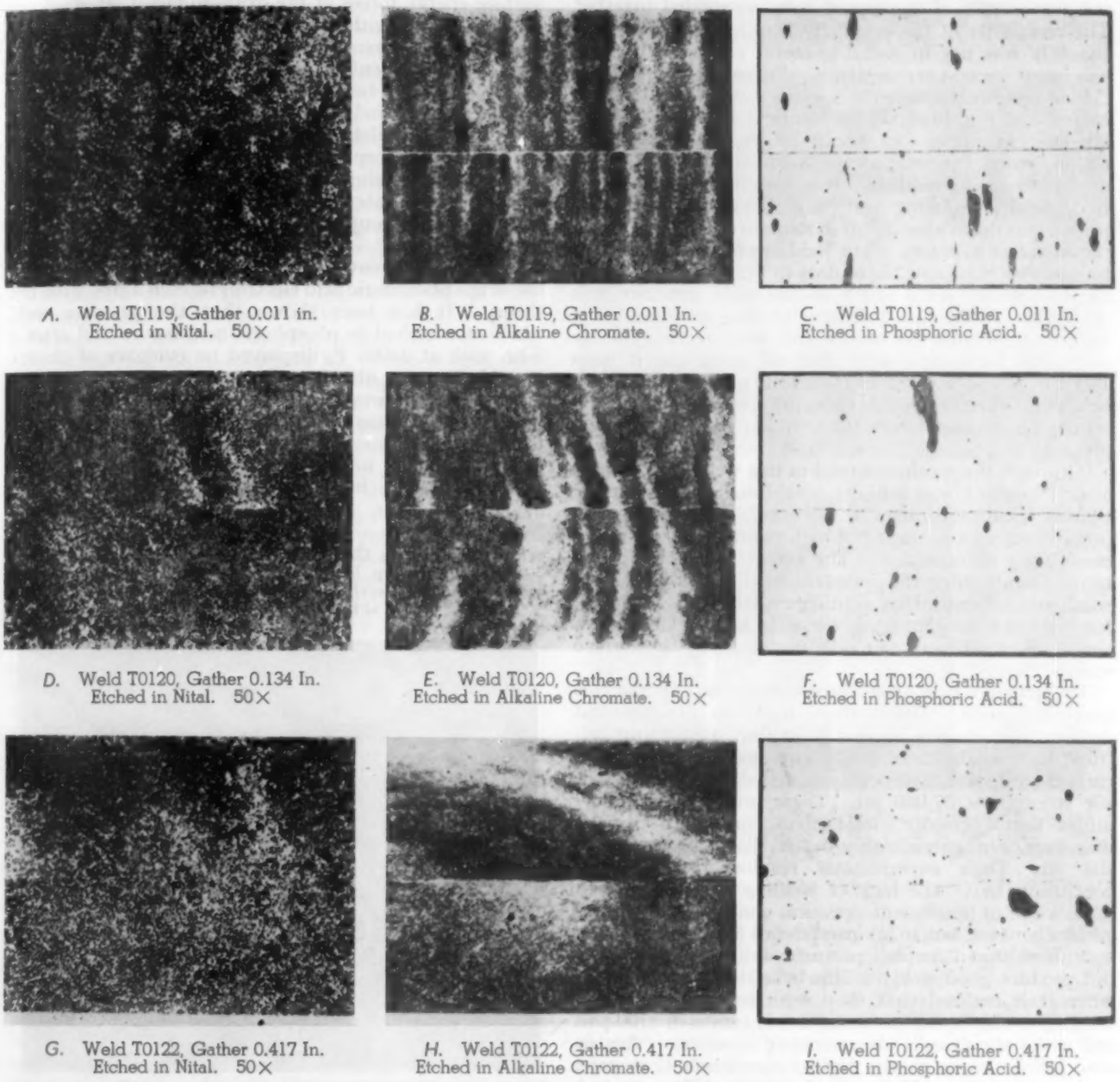


Fig. 23—Face Oxidation Occurring in Parts Which Were Interrupted During the Welding Cycle. Solution of Previously Existing Oxides Can Be Seen in the 30-Sec. Weld. 1×



A. Weld T0119, Gather 0.011 in. Etched in Nital. 50×

B. Weld T0119, Gather 0.011 In. Etched in Alkaline Chromate. 50×

C. Weld T0119, Gather 0.011 In. Etched in Phosphoric Acid. 50×

D. Weld T0120, Gather 0.134 In. Etched in Nital. 50×

E. Weld T0120, Gather 0.134 In. Etched in Alkaline Chromate. 50×

F. Weld T0120, Gather 0.134 In. Etched in Phosphoric Acid. 50×

G. Weld T0122, Gather 0.417 In. Etched in Nital. 50×

H. Weld T0122, Gather 0.417 In. Etched in Alkaline Chromate. 50×

I. Weld T0122, Gather 0.417 In. Etched in Phosphoric Acid. 50×

Fig. 24—Nital, Alkaline Chromate and Phosphoric Acid Electrolytic Etches of Pressure Welds Made with Increasing Gather and Tine

to become spherical. The resultant forces on surface atoms in a direction normal to and outward from the major axis would be greater than the resultant forces in any other direction. Thus, the rate of inward movement at the ends of the minor axis would be less than that at the ends of the major axis as the void decreases in size under the influence of tangential surface energy forces. This tendency can be seen by comparing the general size and shape of voids shown in Figs. 21 and 22. (The weld represented in these prints will be described later.) The specimen held for a longer period of time at 2300° F. in Fig. 22 has smaller and rounder voids. When the combined effect on void size of both surface energy forces and the forces due to upsetting pressure is considered, it would be logical to assume that void size reduction would be greater than if either of the forces acted alone.

In an effort to differentiate between the roles played by mechanical deformation versus deformation induced by surface energy, "pressure" welds were made with the pressure being only that supplied by the force of gravity. These welds were suggested by the work carried on in 1932 by Austin and Jeffries.[9] Pressure thus employed in these welds was extremely low, being in the order of 0.07 psi. based upon nominal areas in contact. The surfaces of two small pieces of NE 8630 steel weighing approximately 5 gm. each were surface ground and then lapped with a very fine lapping compound. After thoroughly cleansing the weld faces, they were placed on top of each other in a carbon combustion furnace. Starting at room temperature, hydrogen was passed through to completely remove all air. The furnace temperature was then raised to 2300° F. where it was maintained for 2 hr. During furnace cooling of the parts, the hydrogen atmosphere was maintained until the specimens cooled to 400° F. Figure 17 shows the welded specimen as it appeared after removal from the furnace. Only about

the center 30% of the lapped surfaces welded together. The remainder of the originally contacting surfaces apparently was not in metal-to-metal contact while the specimens were at temperature. Figure 18 shows a nital etched section through the specimen where welding occurred, and Fig. 19 shows the identical area but etched in alkaline chromate. As would be expected, no light-etching zone is present at the weld, due to the absence of oxygen during welding. It is very interesting to note that ferrite, pearlite (etching black in the nital print), and the Widmanstätten structure all extend across the weld line in places. The weld line is most easily seen by observing the fine line of dots in Fig. 19. The line of ferrite present along much of the weld juncture was probably caused by the decarburizing action of the hydrogen. Figure 20 shows the weld electrolytically etched in phosphoric acid after oil quenching it from 1800° F. A heavy attack on the weld plane was expected because of the dots visible there prior to etching, but the spongy appearance beside the weld line remains to be explained.

Although the specimens used in this weld were lapped, atomic contact was initially established over no more than a small percentage of the area. The initial compressive stresses at these few high points were enough to cause some deformation. The extent of such deformation in establishing the complete weld undoubtedly was small and indicates that another explanation is required for the extensive contact at the weld area. This extensive contact can very nicely be explained by the surface energy theory.

The question may arise concerning the strength of this particular weld. The authors have no experimental data to offer concerning this point, but Austin and Jeffries[9] made welds under similar circumstances using low-carbon steel, and these welds exceeded an ultimate tensile strength of 37,000 psi. These investigators determined that "pressure" welds made in a hydrogen atmosphere were considerably better than those made in the air. Their experimental results justified their conclusion that "the lack of welding was not due to application of insufficient pressure, and hence to lack of surface contact, but to an interference film." They also concluded that "simple" pressure welding in air could not produce good welds. This belief is understandable when it is realized that they were regarding pressure welding as employing pressures not in excess of 1100 psi. and with only a negligible amount of upsetting. Austin and Jeffries came to the logical conclusion that gaps could exist at the weld faces and welding still occur, and speculated concerning the precise intimacy of contact necessary.

In a further effort to study the effects of surface energy, other welds were made in a hydrogen atmosphere as in the preceding section with only the force of gravity supplying the pressure. Weld faces, however, were finished to 2/0 emery only. Figure 21 shows the average size of discontinuities at the weld plane after 7 hr. heating at 2300° F. These discontinuities were voids as would be expected since there was no opportunity for iron oxide formation in a hydrogen atmosphere. Figure 22 shows the extent of size reduction effected by 5 hr. additional heating at 2300° F. The reduction in void size was actually greater than that shown, since many voids disappeared and a field was picked to include larger than average ones appearing in a denser-than-average cluster. These prints show quite clearly the effect of surface energy in reducing the size of voids. It is believed that the same principle applies when FeO inclusions dissolve at high temperatures and metal flows in to maintain the oxide-to-metal interface. The process of particle size reduction can be carried to a point at which surface energy forces at the oxide-to-metal interface are in equilibrium with the plastic strength of the steel. Thereafter, the remaining oxide should dissolve away leaving only a submicroscopic void. It is felt that since voids have been shown to decrease in size due to surface energy, and since the mechanism of oxide solution offers no explanation for the closure of steel around the inclusion (except, perhaps, in influencing the rate of closure by increasing or decreasing surface energy at the oxide-to-metal interface), the same principle applies whether the discontinuity is an empty void or an iron oxide inclusion.

Other experimental observations made through the use of the phosphoric acid electrolytic etch agree with the theory. It has been shown that the pressure weld which was etched in phosphoric acid before and after a 5-hr. soak at 2300° F. displayed no evidence of change in resistance to attack. (Figures 8 and 9 show this fact.) It is believed that the voids neither decreased perceptibly in size or number during the long high-temperature soak. On the basis of the surface energy theory a change would not be expected since approximately the same high temperature was reached when

Fig. 25—Alkaline Chromate Etch of a Weld Made with a 0.015-In. Air Gap Initially Between Faces and Quenched from 2300° F. Merely Traces of Dissolved Oxygen Are Seen at the Weld Plane. 80×

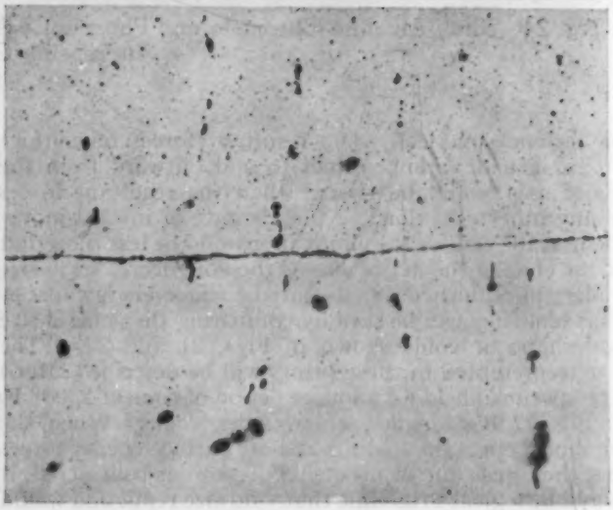


Fig. 26—Phosphoric Acid Electrolytic Etch of the Same Area as Fig. 25. The Etch Has Attacked the Weld Plane Strongly. 80×

the weld was made and, therefore, the size of the void would already have been predetermined by the initial welding temperature, assuming there was sufficient time for the voids to reach an equilibrium size during welding.

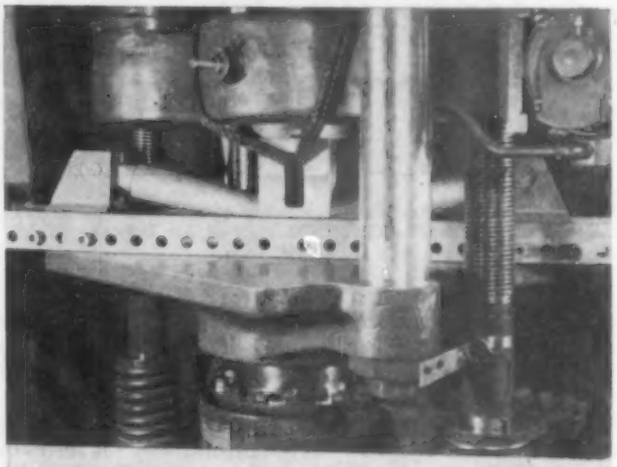
Weld Contaminants

The effect of contaminants is one of the major factors in pressure welding, and of all contaminants, oxygen is of the greatest importance. Oxygen contamination may take the form of a layer of oxide covering weld faces or may be present as a solid solution at the weld. Oxide layers are of primary importance since they necessarily precede oxygen in solid solution, and appear to be fundamental in affecting the mechanism of bonding.

In discussing the mechanism by which oxygen contamination alters the bonding of welds, the extremes in contamination will be considered. In the case of welds capable of developing parent metal strength when statically bend tested at high tensile strengths, relatively little oxide is present as a contaminant. In the welding cycle of such high-strength welds, the initial heating causes weld faces to oxidize slightly, due principally to entrapped air. Such oxide films are very thin, inasmuch as they are manifested by interference colors. Before any upsetting has occurred these films dissolve into the base metal and play no further part as oxides. The completed weld after electrolytically etching in phosphoric acid is shown to be characterized by submicroscopic voids, which persist from original weld face discontinuities. In the case of the very poorest quality welds, however, oxidation is due almost entirely to outside air gaining access to the weld faces. The oxide formed is so extensive that the pieces being welded are effectively separated by it even after upsetting has commenced. The film of oxide finally is ruptured at a vast number of points, metal-to-metal contact being established at the breaks in the film. At the completion of the weld, the oxides appear globular and elongated in the plane of the weld. A phosphoric acid electrolytic etch of these welds results in the removal of a major portion of the weld plane at the surface due to the extensive oxides present. It is quite obvious that conditions of oxidation may vary between these extremes. Where oxidation is less severe it still may interfere with the establishment of metal-to-metal interfaces but the major portion of it may nevertheless be dissolved at the completion of a weld, the only traces remaining being submicroscopic voids, the closure of which surface energy forces could not effect. (This lack of complete closure after diffusion of FeO was previously discussed under "Plastic Deformation Due to Surface Energy.") Phosphoric acid electrolytic etching of such welds reveals not only the voids persisting from the original weld face discontinuities, but those remaining after the solution of oxides, and hence the etching attack appears more severe. Poor pressure welds are usually of this type.

The formation of oxide films and their disappearance by solution have been studied by interrupting pressure welds after very short periods of heating and then, after the parts have cooled, separating the joint to observe the appearance and disappearance of oxide colors. The weld size used for this study was $2^{7}/_{8}$ in. O.D. x $^{9}/_{32}$-in. wall, material being NE 8735. Weld faces were machined flat and normal to the tube axis. With the exception of gather and time, the welding conditions were normal for the tube size. Heat was applied with an external torch only. Time of heating was varied from 10 to 40 sec. in increments of 5 sec. (The normal time required to complete this size weld is approximately 85 sec.) Figure 23 shows the results of these tests. The parts

Fig. 27—Test Setup Used in Statically Bend Testing Pressure Weld Specimens to Destruction. A Part Is Shown After Buckling Failure Has Occurred



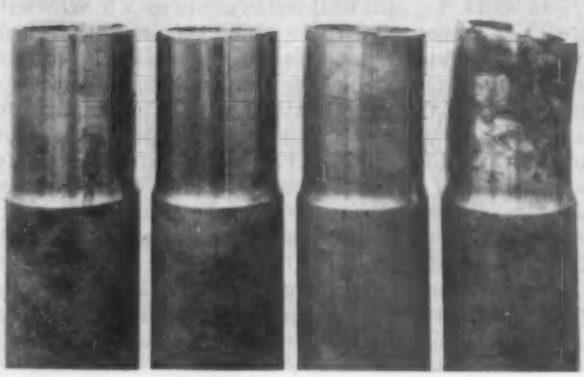
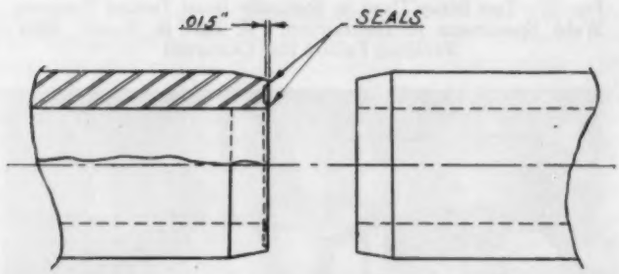


Fig. 28—Pressure Weld Bend Specimens Made with Varying Gather and Which Failed in the Plane of the Weld. The Lowest Strength Weld Is at the Left and the Highest at the Right

heated for 10, 15 and 20 sec. did not adhere. Heating for 25 sec. caused slight adherence at the outer edge of the faces, only a light tap being required to break the halves apart. Heating for 30, 35 and 40 sec. resulted in substantial adherence, a heavy hammer blow being required to separate sections cut from the welds. The fracture of the 35- and 40-sec. welds appeared identical with that of the 30-sec. weld. In Fig. 23, the formation and progressive disappearance of the outer band of oxide can be observed. All of this outer band disappeared after 25 sec. heating; the temperature indicated by the color of the external surface was approximately 1200° F. The specimen heated for 20 sec. did not attain a visible red. The appearance of the inner band of oxide can first be observed in the 10-sec. weld and its disappearance observed in the 30-sec. weld.

These interrupted welds do not necessarily indicate the face oxidation present at instantaneous times during the making of a single weld. Under the test conditions, considerable residual heat was present in the parts after the torch was shut off, and this heat probably affected the face oxidation. They do, however, show that oxides begin going into solution in steel at temperatures below 1200° F. as demonstrated in the 20-sec. specimen.

When dissolved oxygen is detected at the weld plane by means of the alkaline chromate etch, it indicates the presence during welding of an abnormal amount of oxide and the consequent poorer quality of bond established. Such a weld is characterized by an abnormal number of voids, and when the initial film is very heavy, oxide in-



Sketch 2—Illustrating Face Geometry of a Pair of Specimens Designed to Entrap a Given Quantity of Air Between Weld Faces

clusions which were too large to completely dissolve may also be evident in the finished weld. The impact resistance of the oxygen-rich metal finally remaining at the weld plane is much lower than that of the base metal. This decreased impact resistance due to dissolved oxygen has been studied by other investigators.[10, 11] A series of $3^{15}/_{16}$ in. O.D. x $^1/_4$-in. wall welds made in NE 8739 with increasing gather and time while keeping other weld settings constant illustrates such conditions present during welding. In Fig. 24, Plates *A*, *B* and *C* show identical areas of a weld made with 0.011-in. gather. Plates *D*, *E*, *F* and *G*, *H*, *I* show identical areas of welds made with 0.134- and 0.417-in. gather, respectively. The nital etch of each weld reveals nothing of importance, while the alkaline chromate etch shows the occurrence of dissolved oxygen which finally disappears in the weld with the largest gather. This disappearance occurred because diffusion of the oxygen was accelerated by the higher temperature and longer heating time. The correlation of etching attack by the phosphoric acid with the amount of upsetting can be seen. The electrolytic attack can be seen to decrease with an increase in gather, mechanical working and higher temperatures reducing the size of the voids, while the mechanical working alone resulted in a spreading apart of voids.

It is fortunate that pressure welds do have a tolerance for oxygen. Toolmarks in weld faces may be quite deep and entrap considerable air without deleterious effects being felt. The effect of an unusually large amount of air present at the faces during welding, but trapped to prevent replenishment from the outside, was demonstrated in the weld described below. The weld size was $1^1/_2$ in. O.D. x $^1/_4$ in. wall and the material NE 8630 tubing. A lip approximately 0.015 in. high and 0.025 in. wide was machined circumferentially at both the outer and the inner edges of the weld face of one specimen as shown in Sketch 2. During welding, these lips were butted against the flat face of the other specimen, thus trapping air within the cavity 0.015 in. wide. The weld was made under welding conditions producing good welds when using normal specimens. Figure 25 shows the resulting weld etched in alkaline chromate. Merely traces of oxygen can be detected at the weld plane which appears substantially satisfactory. Figure 26 shows an electrolytic phosphoric acid etch of the same area. Attack has taken place which is in excess of that encountered in a good weld made with faces initially in contact, such as shown in Fig. 8. Although entrapped oxygen diffused away from the weld plane before the conclusion of welding, its prior effect in increasing the number of voids is observed in the abnormal electrolytic attack. It is assumed the entrapped nitrogen also diffused into the steel under the effects of heat and pressure, except for a small amount remaining in the voids.

Physical Testing

Physical testing at present is not the most sensitive means for differentiating weld quality. It nevertheless is very necessary for correlating metallurgical changes in welds with physical performance, and for determining whether welds are usable for specific applications. Several bend test runs have been reported previously.[4] However, in this article only one run indicating the general correlation of weld strengths with gather will be discussed.

This run consists of a group of static bend test welds made using a range of gathers in order to establish a manufacturing tolerance. The range of gather used was lower than that required for this size section. Its result on strength is clearly seen. The subject welds were made from NE 8735 and the size during welding was $3^7/_8$ O.D. x $^3/_8$ in. wall. Prior to testing, the specimens were heat treated to 188,000 psi. U.T.S., and then turned to $3^3/_4$ in. O.D. x $^5/_{16}$ in. wall. Full-size static bend testing was carried out as shown in Fig. 27. Ends of the specimens were restrained by plugs which pivot freely in the testing fixture. Load was applied through a saddle straddling the weld and making 180° contact. Table 1 presents the physical testing data and the gathers employed in welding. The weld with the lowest gather broke at the lowest load, strengths increasing progressively with increasing gather. Figure 28 shows the specimens which broke in the weld, the one on the left possessing the lowest strength and increasing toward the right. All but the specimen on the right suffered little permanent deformation before failing, as can be seen. The right-hand weld, T1190, however, buckled considerably before failing. Fracture in the weld plane with deformation is typical of a certain proportion of pressure welds which possess the same ultimate bending strength and tube ductility as those which buckle or fail by rupture in parent metal. (Welds Nos. T1188 and T1189 with gathers of 0.304 and 0.315, respectively, both failed by tube buckling at the same modulus of rupture as did T1190.) Decreased strength in these short gather welds resulted from insufficient bonding and closure of voids and insufficient diffusion of the initial oxide film formed on the weld faces. These factors were caused by low gather with attendant subnormal temperatures.

Table 1

Weld No.	Gather, In.	Ultimate Tensile Strength Based on Rockwell "C" Hardness, Psi.	Failure Load, Lb.	Test Modulus of Rupture, Psi.	Type of Failure
T1185	0.264	188,000	66,800	201,000	Weld
T1186	0.285	188,000	79,500	239,000	Weld
T1187	0.294	188,000	90,500	272,000	Weld
T1188	0.304	188,000	98,800	300,000	Buckle
T1189	0.315	188,000	98,500	299,000	Buckle
T1190	0.334	188,000	98,300	299,000	Weld (after considerable deformation)

Many of the aspects of oxyacetylene pressure welding presented in this paper are with reference to welds which must consistently possess 100% static bending strength. The tubular welds discussed are, in general, much more difficult to properly make than are solid section welds, especially when only exterior torches are employed. Although initially disadvantageous, these necessities have made possible a fuller understanding of the more intricate phases of pressure welding. With the accruing knowledge of the effect and relative importance of the various factors involved, the process can be applied in industrial fields where performance requirements range from the highest to the lowest. It is hoped that this paper will assist in extending the presently limited industrial utilization of pressure welding.

References

1. Fine, Leslie, "A New Reagent for Detecting Oxygen Segregations in Steel," *Metal Progress*, January 1946.
2. Voldrich, C. B., and Zambrow, J. L., *Evaluation of the Quality of Pressure-Welded Joints in Alloy Steels, and of the Ease of Production Control of the Process*, WPB Research Project NRC-558, WPB-177, August 31, 1945.
3. Kinzel, A. B., "Solid-Phase Welding," THE WELDING JOURNAL, December 1944.
4. Fine, Leslie; Maak, Charles H.; and Ozanich, Anthony R., "Metallurgical Aspects of High Quality Pressure Welds for Landing Gear," *Metal Progress*, February and March 1946.
5. Wulff, John, *Powder Metallurgy*, American Society for Metals, 1942, pp. 43–45, 54–57.
6. Beilby, George, *Aggregation and Flow in Solids*, MacMillan and Company Ltd., London, 1921.
7. Desch, C. H., *Jour. Chem. Soc.*, **123**, 280 (1923).
8. Adam, N. K., *The Physics and Chemistry of Surfaces*, Oxford University Press, 1938.
9. Austin, C. R., and Jeffries, W. S., *Pressure Welding of Low-Carbon Steels with Theoretical Considerations*, A.I.M.E. Tech. Pub. 451, 1932.
10. Tritton, F. S., and Hanson, D., "Iron and Oxygen, Ferrous Alloys Research," *J. Iron and Steel Inst.*, **110**, pt. II, No. 2, 90 (1924).
11. Herty, C. H., Jr., Gaines, J. M., Jr., Larsen, B. M., Simkens, W. A., Geruso, R. L., and Watkins, S. P., *The Physical Chemistry of Steel Making; The Solubility of Iron Oxide in Iron, Mining and Metallurgical Investigations*, Cooperative Bulletin 34, U. S. Bureau of Mines, Carnegie Institute of Tech., and the Metallurgical Advisory Board, 1927.

"Shooting Star" Engine Is Triumph for Modern Welding

By J. G. Shaw, Jr.*

UTILIZATION of many specialized types of welding to produce joints of great strength in lightweight metal was one of the main factors in the successful development of the General Electric Type I-40 jet propulsion gas turbine, which powered the Lockheed Shooting Star on its recent record-breaking transcontinental flight.

The plane flew from Long Beach, Calif., to La Guardia Field, New York, in 4 hr., 13 min. and 26 sec., averaging 584 miles an hour on the trip and at times reaching speeds in excess of 600 mph.

One of the chief features in the all-welded construction engine, besides the lightweight metals used, is the extremely favorable horsepower-weight ratio of better than two horsepower per pound, as compared with one per pound in reciprocating type engines.

There are more than 500 welded joints in the engine, and in making them practically every known type of welding was utilized, each one in applications where its particular advantages could best be employed. For example, the circular seam welding of a flange to the outer exhaust cone is done by resistance seam welding, and many parts in the exhaust unit assembly itself, where pressure-tight welds are not required, are spot welded.

Since the intense heat of the combustion creates very high operating temperatures (about 1500° F.), heat-resistant alloys are required for the combustion chamber and the exhaust unit. In order to keep the weight of the engine down, these heat-resistant alloys were used in sheet form, some as light as 0.022 in. in thickness.

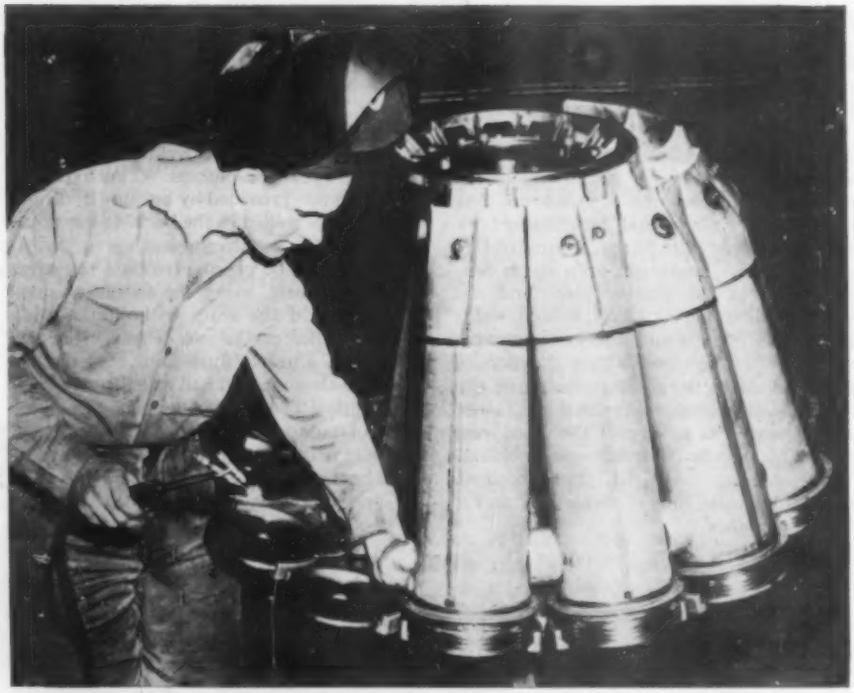


Fig. 1—Placing Combustion Tubes in Fixture Tubes for Aircraft Gas Turbine. Taken at ITE Circuit Breaker Company, Subcontractor Fabricator

These austenitic stainless alloys give high strength and good corrosion resistance at high temperature. By welding these parts the engineer was able to design for minimum weight with maximum joint efficiency, both in thermal strength and physical strength.

Fabrication of various parts out of sheet metal, however, led to one of the real production problems and it was only through

* Press Relations Division, Apparatus Department, General Electric Co., Schenectady N. Y.

Fig. 2—Welding Cross-over Tubes to Flame Tubes by Atomic Hydrogen Process

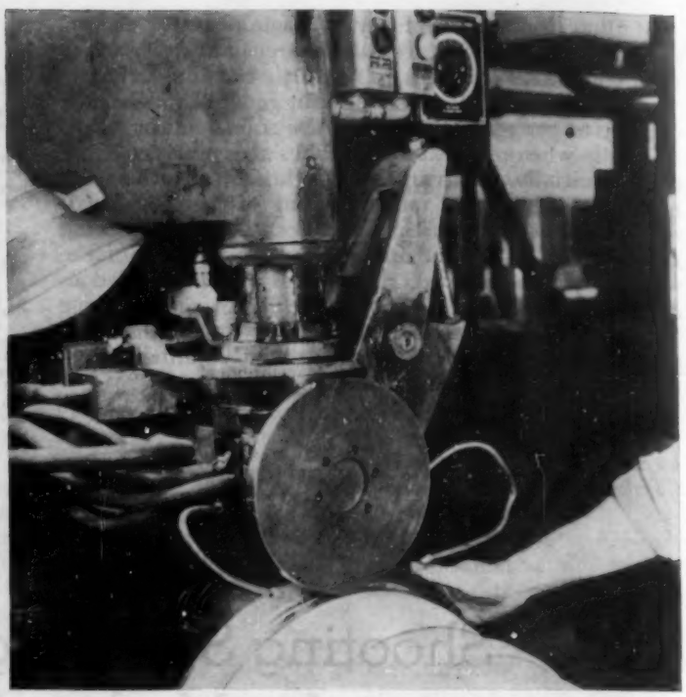


Fig. 3—Circumferential Seam Welding of Large Flange to Cone Assembly

the closest cooperation between the design engineers, manufacturing department and the welding engineer that the correct procedure for making parts was finally established.

The fabrication included joint design, fixturing, welding process and machining procedure. In considering joint design, it was first necessary to design for strength. Then weight, distortion and gas flow were closely checked. For example, in a joint where it was necessary to join pieces of different thicknesses, it was known that minimum weight would be obtained by using a straight butt joint. A joint of this type, however, would set up a stress concentration in the thinner piece and encourage failure in service. Fusion welding of this joint would also cause greater distortion. Therefore, where the flanges were welded to the exhaust casing or the ring holders as well as to the flame tubes, a lap joint was used and the weld was generally made by resistance seam welding. This joint proved tight, had excellent strength, a minimum of distortion, and a neat appearance.

In cases where there was great variation in thickness, it was possible that fatigue failure would occur in the thinner section, next to the lap. Because of this, it was desirable to keep both pieces as nearly alike in thickness as possible. The longitudinal seams, in some instances, were designed for a flush joint without the necessity of grinding. These were made by clamping the joint in a fixture and backing it with hydrogen, and then welding it by the atomic-hydrogen process. The hydrogen backing was provided by burning hydrogen in a groove milled in the backing bar of the fixture. On the thicknesses up to $^1/_{16}$ in., it proved to be possible to butt the edges up square and, using the fixture as mentioned, weld the seam without the addition of filler or the use of flux. This resulted in a nearly flush joint that did not require cleaning and had excellent physical strength. The use of filler was eliminated by clamping both sides of the joint tightly within $^1/_4$ in. of the joint. Bringing the heat of the arc to the metal expanded it and forced it to hump at the joints. This hump was melted down, giving a flush weld. As the metal cooled, a little elongation occurred between the clamps, but this was so slight that it had little effect upon the strength of the joint. In some cases where a fillet weld was necessary between sheet stock and a heavier section, the metal arc welding process was used to good advantage.

It is axiomatic that distortion caused by welding, especially in sheet metal parts, is practically unavoidable. In order to make use of the advantages of these parts, however, allowance had to be made for this distortion wherever possible. When this allowance could not be made, however, it was possible to reduce the distortion by using proper fixtures and sequence. In some cases, welding sequence can be used to reduce distortion and machining sequence to correct it.

By careful planning of operations in manufacturing the Type I-40 engine, it was possible to solve these problems and to make parts according to the manufacturing drawing, in spite of the many problems encountered in welding on sheet metal.

Some Results of Advances in Welding and Radiography on the Welding of Pressure Vessels*

By O. R. Carpenter†

THE published title of this paper has been changed to a more appropriate one, namely "Some Results of Advances in Welding and Radiography on the Welding of Pressure Vessels." When considering what I might have to say, I concluded that of greatest interest with respect to the advances of steel weldments in recent years was the effect of the improvement of radiographic technique and of our better understanding of the art of fusion welding on obtaining sound welds. A full discussion of this subject would cover a considerably larger field than is desired and I have, therefore, chosen first, a discussion of radiographic technique as it pertains to pressure vessels; second, some brief facts concerning our methods of welding today; third, a type of defect now most troublesome together with a speculation as to its cause, and finally a recently developed method of inspection with which we hope to qualify or perhaps eliminate this particular trouble in the welding of pressure vessels.

Most of you here today are familiar with the many-times-told early history of the application of nondestructive testing to pressure vessel construction. For the sake of clearness, I should like to repeat briefly some of its high points. During the period of 1926 to 1929 the pressure vessel manufacturers were considering the use of fusion welding as a method of construction in place of riveting. Welding methods were being studied and improved. Some welded vessels were built and placed in service although there was considerable apprehension as to weld quality. Numerous tests of fatigue strength, physical tests and rupture tests on full-size drums were made. The construction codes, however, would not accept the method unless some nondestructive means of testing could be found.

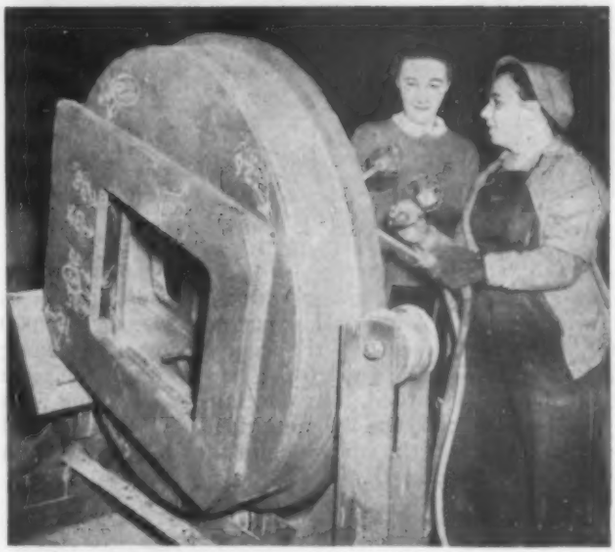


Fig. 2—Magnetic Testing of Base Rings

Many methods were tried. One interesting one was the use of a strethoscope and was then known as sonic testing (Fig. 1). In this test the operator tapped the questionable area with light hammer blows and listened to the tone by means of the stethoscope. If it were dead or absorbed, it was assumed that the weld was defective. Although crude in its method, the principle was good and will be demonstrated so later in this paper.

Magnetic methods were investigated. The technique used was the same as that we are familiar with and make extensive use of today. The results obtained in these first applications were poor largely due to the lack of the efficient iron powders we now have available. Figure 2 shows the application of the magnetic inspection method to a base ring for a 5-in. gun mount. The present efficiency of this method is very well demonstrated by the wide use made of it in this particular application during the war.

Another method which was investigated was the Sperry electric method. This method is now used very successfully in the examination of railroad rails. An

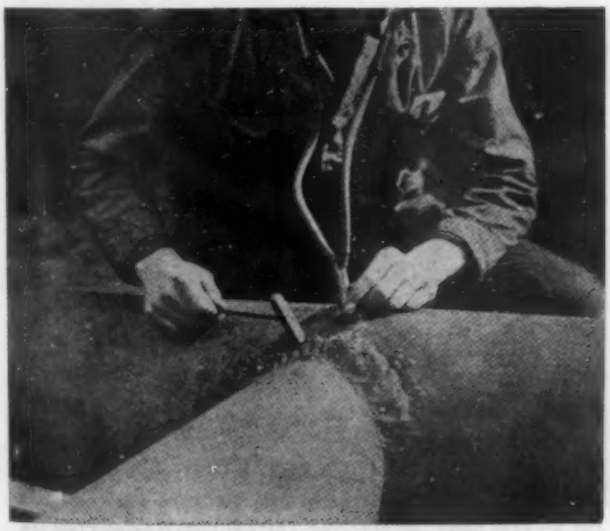


Fig. 1—Stethoscope Method of Testing

* The Second Lester Lecture, American Industrial Radium and X-ray Society. Presented at Cleveland, Ohio, Feb. 6, 1946.

† Babcock & Wilcox Co., Barberton, Ohio.

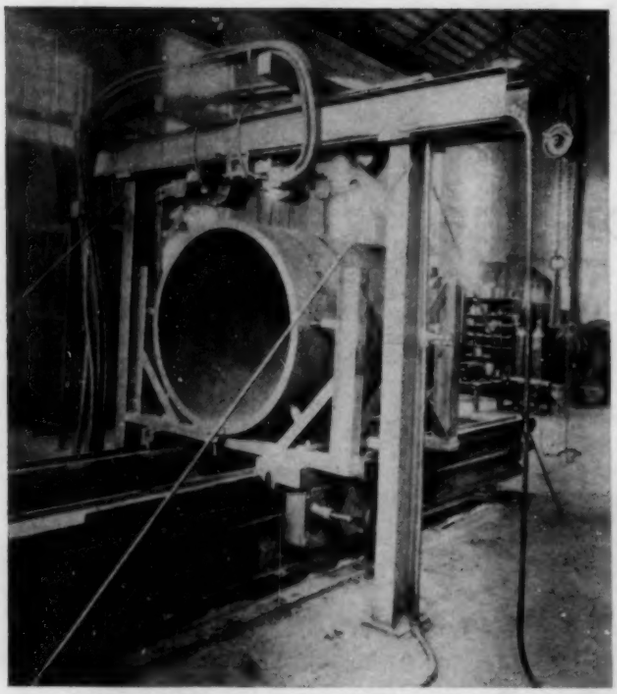


Fig. 3—Sperry Electric Method of Testing

early arrangement for testing welds in this manner is shown in Fig. 3. A heavy d.-c. current, 25,000 to 30,000 amp., was passed through the weld setting up a strong magnetic field. When a defect is in the weld, the path of this field is disturbed. By continually exploring with a small search coil, the magnetic field disturbances will set up a current in the coil which in turn was shown by a recording milliammeter.

Fig. 4—Porosity Film of 10 Years Ago

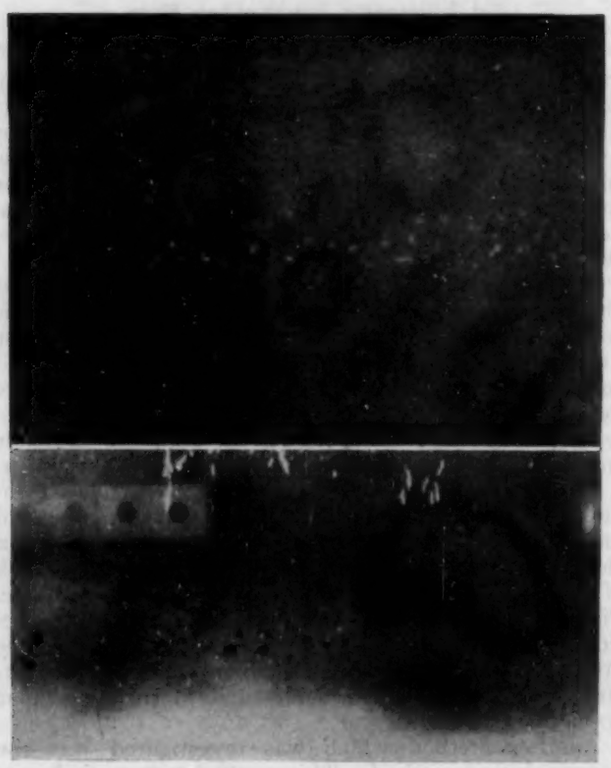


Fig. 5—An Early Porosity Standard

Fig. 6—Large Steam Drum for High-Pressure Boiler

Fig. 7—Large Refinery Tower

While trials of these and other methods were in progress an investigation into the possibilities of X-ray was also being carried out. It is my understanding that Dr. Lester at the Watertown Arsenal had made use of radiography for casting examination sometime earlier than 1925 and that by then he had installed there a 200-kv. X-ray machine. During the next few years he and others were very active in doing the early radiographic work which ultimately demonstrated that this method was the most acceptable one for testing fusion welding. As a result of this work the Navy and later all other construction codes for pressure vessels accepted fusion-welded drums providing they were radiographed.

Soon after its acceptance, the Boiler Code formed an X-ray Subcommittee for the purpose of establishing suitable defect standards for welds and for deciding upon a minimum technique requirement. A review of the proceedings of the early meetings of this committee is very interesting. A typical example of what was then being considered as acceptable porosity in a weld is shown in Fig. 4. Figure 5 is very typical of what was borderline porosity and one which then caused a good

Fig. 8—Free Bend Test of 6½ In. Thick Fusion-Welded Pressure Vessel

Fig. 9—Group of A.S.M.E. Pressure Vessels

deal of deliberation. My first acquaintance with Dr. Lester was made at some of the earlier meetings of this committee. The membership was made up of a group of pressure vessel users and manufacturers together with several members who could be considered neutral and Dr. Lester was certainly one of this group. The subjects which merited the fullest discussions were those of an acceptable porosity standard and a suitable sensitivity gage. I think Dr. Lester deserves considerable credit for his efforts in this respect and I should say that the present penetrameter and porosity standard are largely due to his work.

Following the acceptance of fusion welding, the pressure vessel industry rapidly began to increase design pressures, physical size of vessels, and to introduce complicated designs heretofore impossible. The present outcome of this trend must be far beyond the expectations of those who first considered the use of welding and it is of interest to study for a moment a few types of vessels being built by welding today. Figure 6 shows the steam drum of a large central station boiler. It is about 60 ft. in length and 7 ft. in diameter; it operates at about 1500 lb. pressure. The main shell is made up of 6 courses or rings rolled from flat plate so that, in welding the drum, 6 longitudinal and 7 circum erential welded seams are made. The heads are hemispherical and are formed from flat plate under a 5000-ton press. This drum is built in

Fig. 10—Radiograph of Defective 1-In. Thick Plate

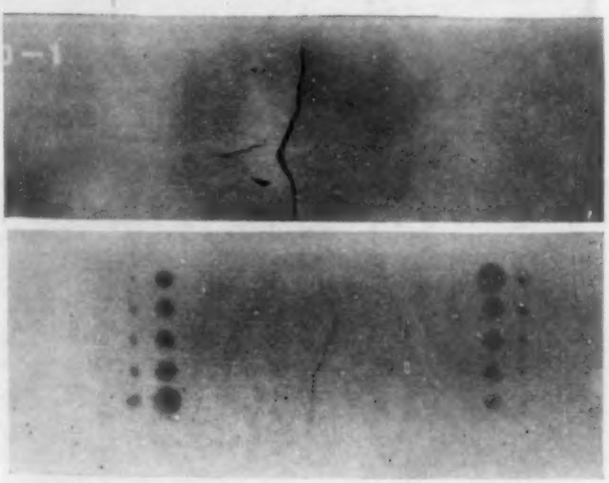


Fig. 11—Radiograph of Plate Shown by Fig. 10 with 3-In. Thickness Added; Bucky Grid Used

accordance with the A.S.M.E. Boiler Code. All seams have been radiographed, the drum stress relieved and hydrostatically tested.

Figure 7 shows a large scrubber tower for use in a refinery. It is about 8 ft. in diameter and 80 ft. in length. It is constructed in much the same manner as the boiler drum just described. All seams have been welded by automatic methods. They have been radiographed, stress relieved and tested in accordance with code requirements.

Welded pressure vessels have been constructed which weigh over 200 tons. Some have been made having welds $6^1/_2$ in. thick and have been completely radio-

Fig. 12—Radiograph of $6^1/_2$-In. Plate Taken at 1 M. Volts

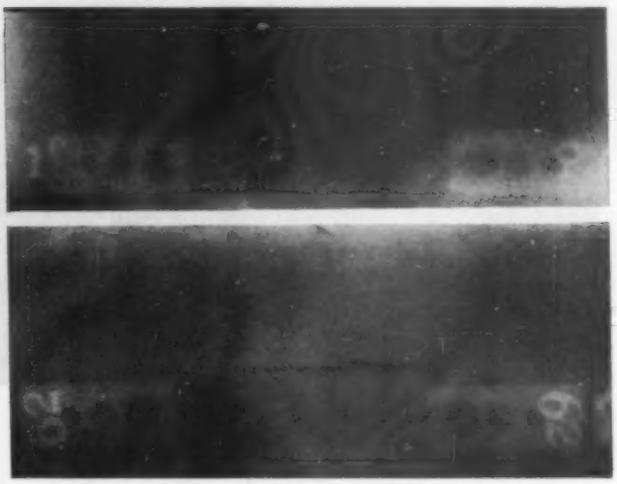


Fig. 13—Radiograph of $6^1/_2$-In. Plate Taken at 2 M. Volts

Fig. 14—Radiograph Showing Weld Defects Resulting from Plate Segregations

graphed and tested. Figure 8 shows a full-size free bend test from the production test plate of such a vessel. This weld has 45% elongation across the outside fibers.

Figure 9 is a photograph of a group of small pressure accumulators of various shapes and ranging to just over 1 in. in thickness.

When radiography was first adopted for the examination of welds, it was a sufficient miracle for a piece of steel to be penetrated and examined by this radiation without too many additional thoughts concerning the technique used. The practice adopted was that then used for medical work. Only one grade or type film was available which used calcium-tungstate intensifying screens. There resulted a coarse-grained radiograph

Fig. 15—Macrograph of Multipass Arc Weld Showing Defects Caused by Plate Segregations

Fig. 16—Macrograph of Multipass Arc Weld Showing Defects Caused by Plate Segregations

with reasonably good contrast but with very poor detail. The early tubes were medical types with large focal spots. The first machine installed in the author's plant in 1929 used an early 200-kv. therapy tube. It was advertised by us as good for the examination of 3-in. welds. Such thicknesses were examined in fact. Questions sometimes arose at that time as to why certain types of defects were not readily found. The sectioning of test plates which appeared very satisfactory on a radiograph made in these early times often revealed a fine line of lack of fusion for the full length which could not be missed by today's practices.

Very little change in industrial technique took place for 5 to 6 years. Higher voltage tubes were developed and in about 1937 we first began to use 400 kv. Secondary and scattered radiation began to get more consideration and for its control the industrial Bucky grid was developed. How successfully it worked is demonstrated by Figs. 10 and 11. Figure 10 is a reproduction of a film of the exposure of a 1-in. test block containing certain prepared defects. Figure 11 is a reproduction of

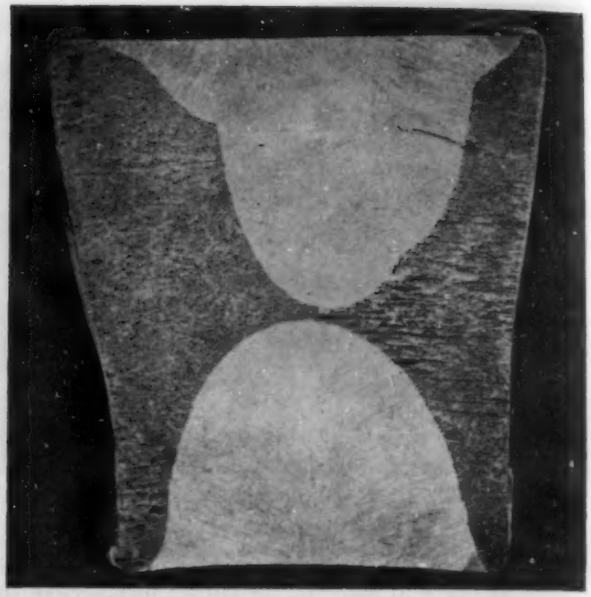


Fig. 17—Macrograph of Experimental Submerged Arc Weld Showing Effect of Inclusions

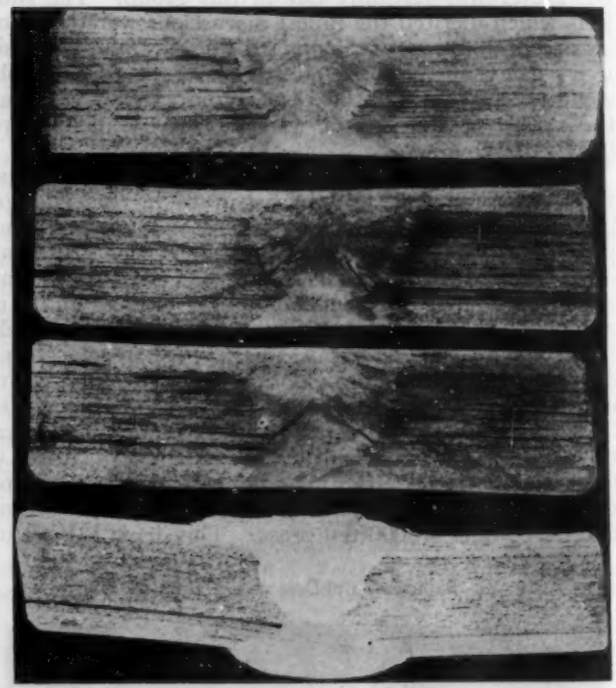


Fig. 18—Macrographs of Sections of Welds in a Rimmed Steel Plate Showing Effect of Segregations

100× 100× 500×

Fig. 19—Micrographs of Plate Showing Inclusions

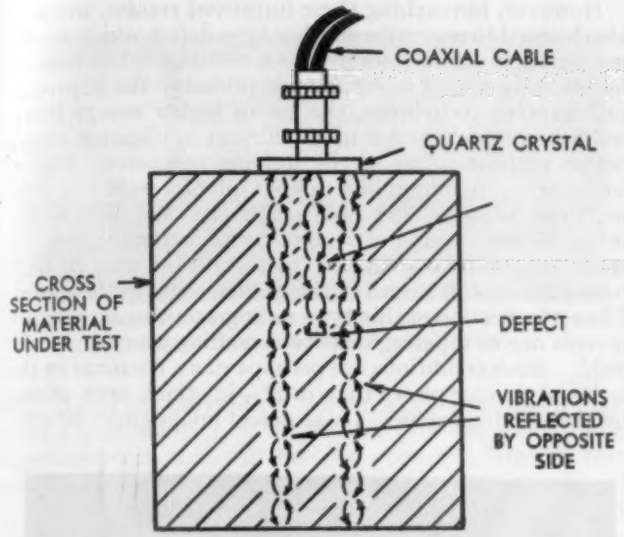


Fig. 20—Diagram Showing Principle of Operation of Sperry Supersonic Reflectoscope

a radiograph of the same plate after a 3-in. thick piece had been added to the film side. It was exposed using a Bucky grid. The loss of detail is very evident.

Real advances in radiographic technique began, in my opinion, when the no-screen type film first became available. This must have been sometime in 1939. Shortly afterward, in 1941, the million-volt machine was developed and placed in service. The use of this machine clearly indicated the need for more than one-grade film for different voltages, techniques and circumstances and shortly afterward the film companies ful-

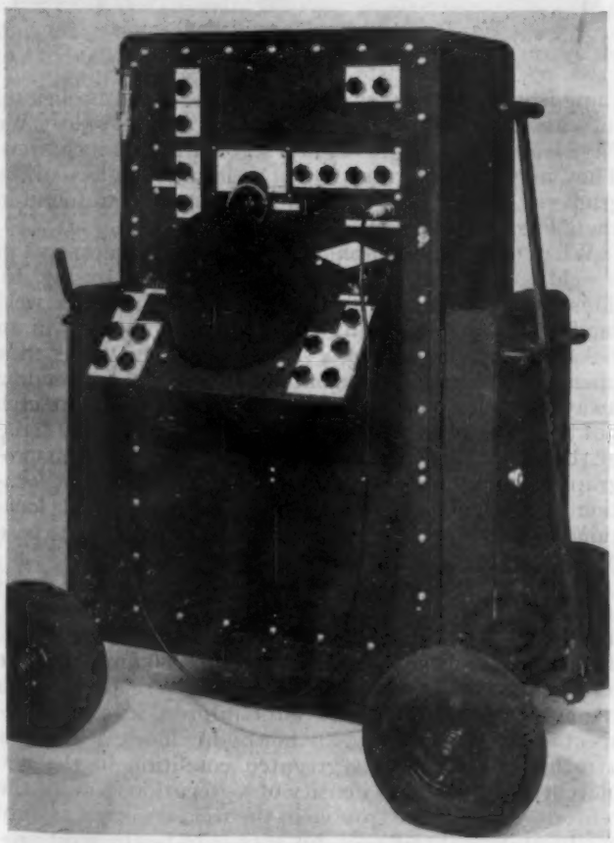


Fig. 21—Photograph of Sperry Supersonic Reflectoscope

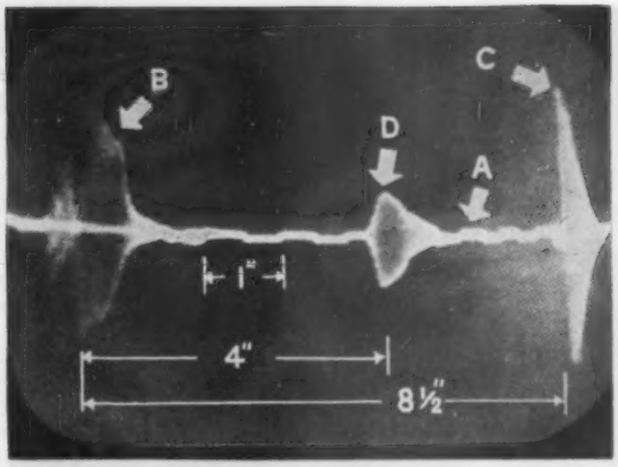


Fig. 22—Explanation of Wave Diagram

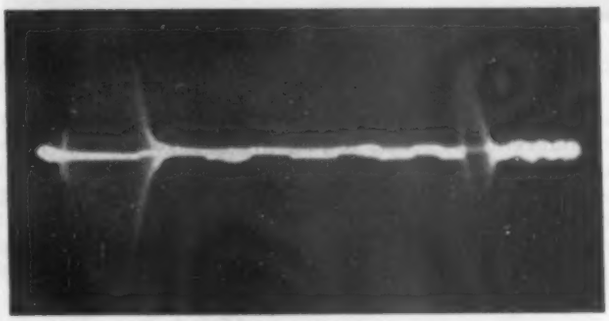


Fig. 23—Normal Wave Diagram

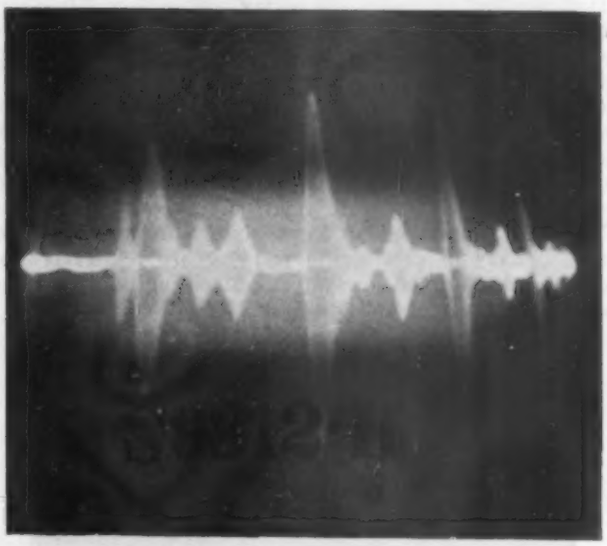


Fig. 24—Part-Reflection Type Wave Diagram

filled this need. This meant considerable in the improvement of radiographic techniques. The former conception that 2% sensitivity is a good radiograph no longer holds. Good work today usually will mean a sensitivity of less than one-half of 1%.

Since the development of the million-volt machine, a two million-volt has been available. The further improvement resulting from the use of 2M.-volt equipment in the radiographic examination of thick welds is well illustrated by Figs. 12 and 13. Figure 12 shows a radiograph taken at 1M. volts of a $6\frac{1}{2}$-in. thick test block in which a crack has been prepared. Figure 13 shows a radiograph of the same test block X-rayed with the 2M.-

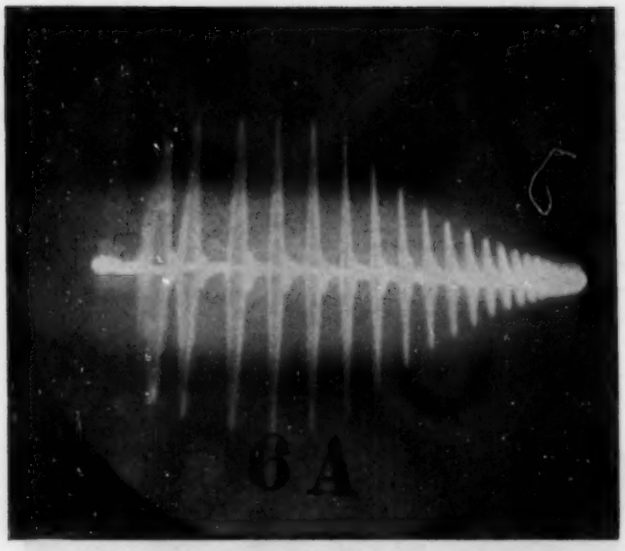


Fig. 25—Absorption Type Wave Diagram

volt machine. The improved detail of the latter is very pronounced. It seems to indicate that for certain peak voltages there are maximum thickness ranges which can best be radiographed. The betatron is now making available for radiographic purposes X-rays generated at voltages from 5M. to 100 M. It will be interesting to learn what this radiation will mean to radiographic examination of pressure vessels.

During the period of radiographic advances just discussed, welding methods and our understanding of the art of welding have also advanced. But as in any process, as we learn more about what happens in a weld we also find new problems which had heretofore not been recognized. In looking back at the welding art of 6 to 7 years ago all will agree that the particular problems then were those of weldability of material, the mechanics of making a good weld and the tools then available to work with. Few will deny that welds completely free of slag, porosity and cracks were relatively rare at this time. Today, while problems of weldability are still with us, gross defects in production welding are relatively uncommon and a good many feet of welding is often done which is radiographically perfect.

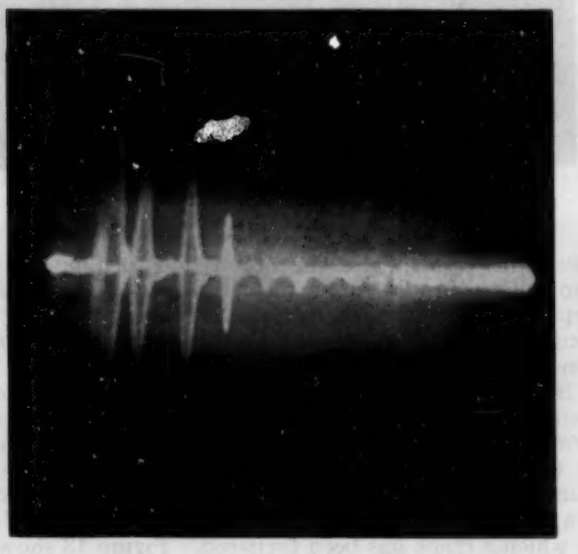


Fig. 26—Absorption Type Wave Diagram

However, in reaching these improved results, we have also learned to recognize another type defect which we did not notice in earlier uses of fusion welding. The reasons for its more recent recognition is probably the improved radiographic techniques, the use of higher energy input welding methods and a more efficient application and a better understanding of the welding processes. Figure 14 is the reproduction of a radiograph of a weld in a $2^1/_2$-in. thick plate. This radiograph shows a line which might be interpreted as lack of fusion extending for the entire length of the film. This condition was, in fact, found for the full length of the welded seam in this drum. Close observation of this type radiographic image usually reveals one of tapering density extending away from the weld. Such conditions are perhaps more common in the welds of thinner plates than in $2^1/_2$-in. thick ones shown by these radiographs. These defect images may be anything from a continuous straight line to small broken-up indications scattered along the length of the weld. We have learned to call them plate segregations or inclusions. They may occur in any type of weld made in any of the grades of carbon steel plates. They are seldom found in the alloy steels.

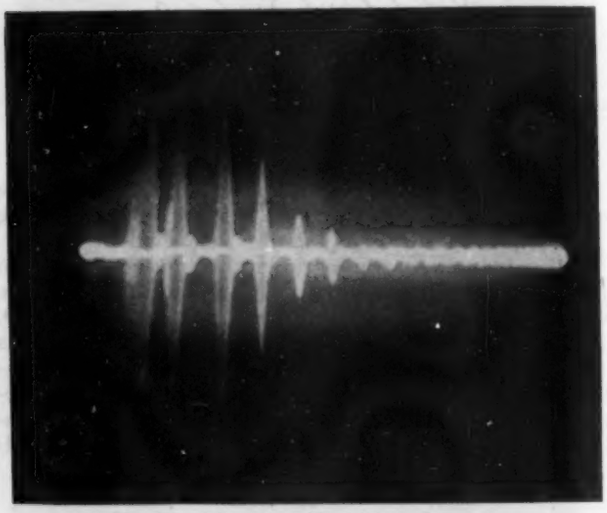


Fig. 27—Absorption Type Wave Diagram

What these radiographic images actually represent in a weld is depicted by the macrograph shown by Fig. 15. This shows a macrograph of a section through a weld made by a multipass automatic open arc method in an S.A. 212 grade steel plate. It shows clearly a rather wide opening in the base plate outside of the weld extending away from the line of fusion. This has had a light etch but the slightly segregated condition of the plate material at the left side may be observed. Figure 16 is a macrograph of a section of the same plate at a different location along the weld. You will observe that at this location small columnar cracks appear and begin in the base plate and extend into the weld.

Figure 17 is a macrograph of a section of an experimental submerged arc weld in a $2^1/_2$-in. thick plate. This weld was also made in S.A. 212 grade steel plate. The bottom pass was deposited using 1700 amp. and the outside has been welded by a number of relatively high current passes. This weld is of interest in several respects. First the etching by hot hydrochloric acid shows a rather continuously segregated condition in the one plate with the greatest density of segregations toward the center. Second, the trouble in the weld occurred at only one location and this does not appear to be the most pronounced of the segregated areas and, upon close observa-

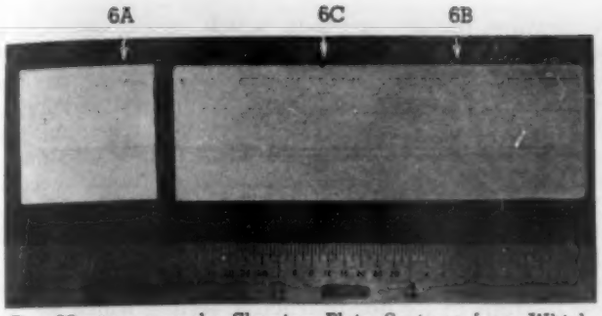


Fig. 28—Macrographs Showing Plate Sections from Which Absorption Type Diagrams Were Obtained

tion, this is the only one of the streaks shown which may extend past the line of fusion and into the weld. The significance of this will become apparent later in this paper.

The grade of steel used has considerable influence upon the amount of this trouble to be expected. The S.A. 212 or 201 grades are silicon-killed steels and are the best available from the standpoint of freedom from this condition. The semikilled steels may or may not be as satisfactory as the killed steels depending upon the mill practice used. These or rimmed steels are known as S.A. 70 grades. Our experience indicates that rimmed steels are the most likely to give trouble due to the high concentration of segregations in the core. Figure 18 shows a series of macrographs of sections cut from an experimental rimmed steel plate, half of which was submerged arc welded and half multipass open arc welded. These macrographs have been etched in hot hydrochloric acid. At first glance the submerged arc welds appear to have suffered considerably more from the inclusion condition than the multipass weld. This, however, is not necessarily the case for, you will note, the etching indicates that the amount and the intensity of the inclusions is very much less in the base material of the multipass weld than in the rest of the plate.

One may assume this to mean that there is a certain concentration of inclusions or let us say scattering of inclusions in a plate which will not cause trouble in the weld. This may have some significance as will be pointed out later in this paper.

It is generally accepted that these cracks and voids, such as have been shown, originate from sulphide inclusions which may be arranged in segregated bands or streaks in the plate material. A condition of this nature is shown clearly by Fig. 19 which shows several micrographs of sulphide segregations in a semikilled steel plate. The etched micrograph shows these inclusions at high magnification. The void shown in the unetched micrograph is the tail of a plate void, resulting from sulphides at the fusion line of a weld.

The formation of these cracks and voids is almost certainly due to the oxidation of the sulphides into an SO_2 gas which then forms in pockets and these, under high pressures, actually cause failure and the opening up of zones of weakness in the plate at the inclusion areas or in the weld metal along columnar grain boundaries. In multipass open arc welding these results often are not as serious as in submerged arc welding because the fluxes used by this method are usually reactive enough to take care of the SO_2 gas as quickly as the oxidation of the sulphides produce it. As the weld deposit passes the point of origin of the sulphide there may remain, however, enough heat and oxygen present to further produce SO_2 from any remaining sulphides causing a void at the fusion line and, in fact, it will sometimes cause a series of surface holes in the deposited bead of metal which are not evident until this has had the slag removed. That is there has not been any evidence of the occurrence of holes by observation of the weld crater during welding.

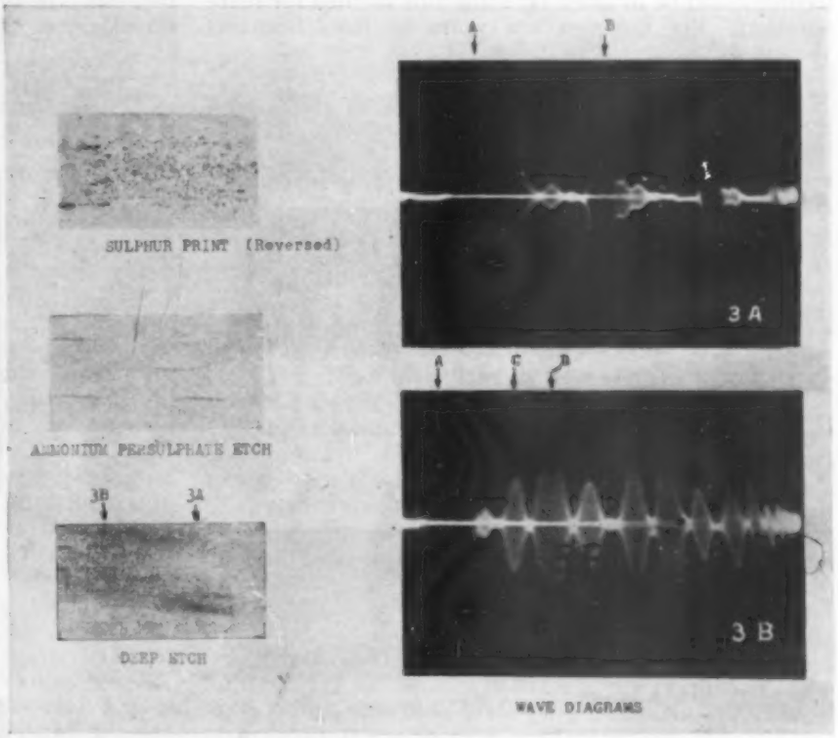


Fig. 30—A Study of Segregation Condition in 1¼-In. Thick Plate

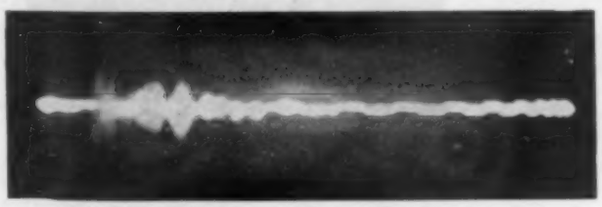


Fig. 29—Full Absorption Type Wave Diagram

In submerged arc welding the flux sometimes used is a completely reacted one which, even when brought to high temperatures, does not give off any appreciable quantities of gas. When it is melted and maintained in a molten state during welding, exceptionally suitable conditions are provided so that high weld currents can be used. This intense heat in the weld zone melts a large volume of parent metal, as compared to other welding methods, so that where sulphides may be present in the base material a greater quantity of these are taken into the weld metal than would be experienced with other methods. It follows therefore, that in using this method of welding more SO_2 gas may be evolved from the parent metal, that, since the flux is fully reacted, no means is provided by the flux

to take care of such gas as may be evolved from the plate and since these welds have a distinct dendritic structure, there may result an entrapment of gas in the zones of weakness along the dendritic planes which in this type of welding are of greater extent than similar structure in multipass, low current welds.

It is known that certain amounts of sulphur in steel have no deleterious effect upon the weld. The plate material used will average 0.04 sulphur or less. It has been shown, however, that local regions of sulphide inclusions may run as high as 0.12 to 0.15 sulphur. It is reasonable to assume that if concentrations of these inclusions are not too great, they will not give any trouble in welding but, as the unetched micrographs have shown and as most sulphur prints will indicate, these segregations may appear in plates in bands or in concentrations. When areas of this type are contacted by the heat of welding the concentration of sulphur is often more than can be taken care of by the process, and the cracking trouble which has been described takes place. Figure 17 might be considered typical of this condition.

If a method could be found which would show in a nondestructive manner the condition of a plate with respect to segregation concentration or banding prior to welding, many hours of repair work and welding trouble could be avoided by using this method for plate selection. For the past few years we have been investigating testing methods which might serve this purpose. Magnetic tests of plate edges were first tried. Indications obtained were correlated to X-ray results but the relationship was found to be too indefinite. Plate edges were carefully polished and etched and the subsequent examination compared to radiographs made following welding of the plate but without success. Deep etching and localized fusion of the plate edges by means of an acetylene torch failed to give results. A black light or the Zyglo method was no more successful.

During December of last year my company secured a new instrument for nondestructive testing which we believe may enable us to study successfully the edges of plates and obtain at least a qualitative indication of the concentration of segregations along the welding edge. Our experience with it of course is limited and we would not care to state a final conclusion as to what may develop from this work. We can say, however, that the work accomplished to date is encouraging. I believe those who have encountered plate defects such as have been described will agree that a method for the evaluation of them is more than worth while.

The instrument I refer to is the Sperry Supersonic Reflectoscope. Many of you are no doubt familiar with it and the many applications made of its principles during the war. Figure 20 gives the principle of operation of the machine. It is to send supersonic vibrations through

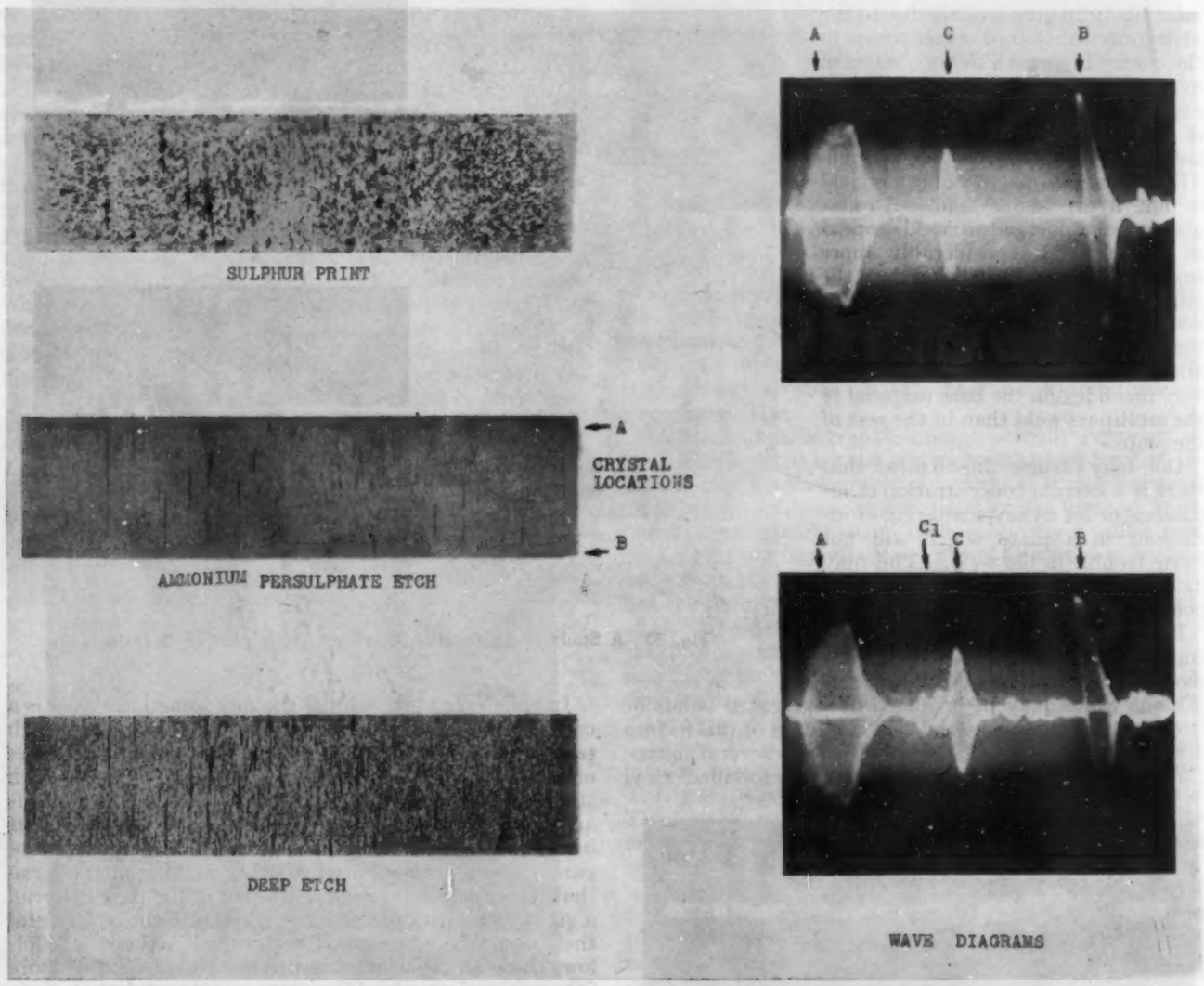


Fig. 31—A Study of Segregation Condition in $4^1/_2$-In. Thick Plate

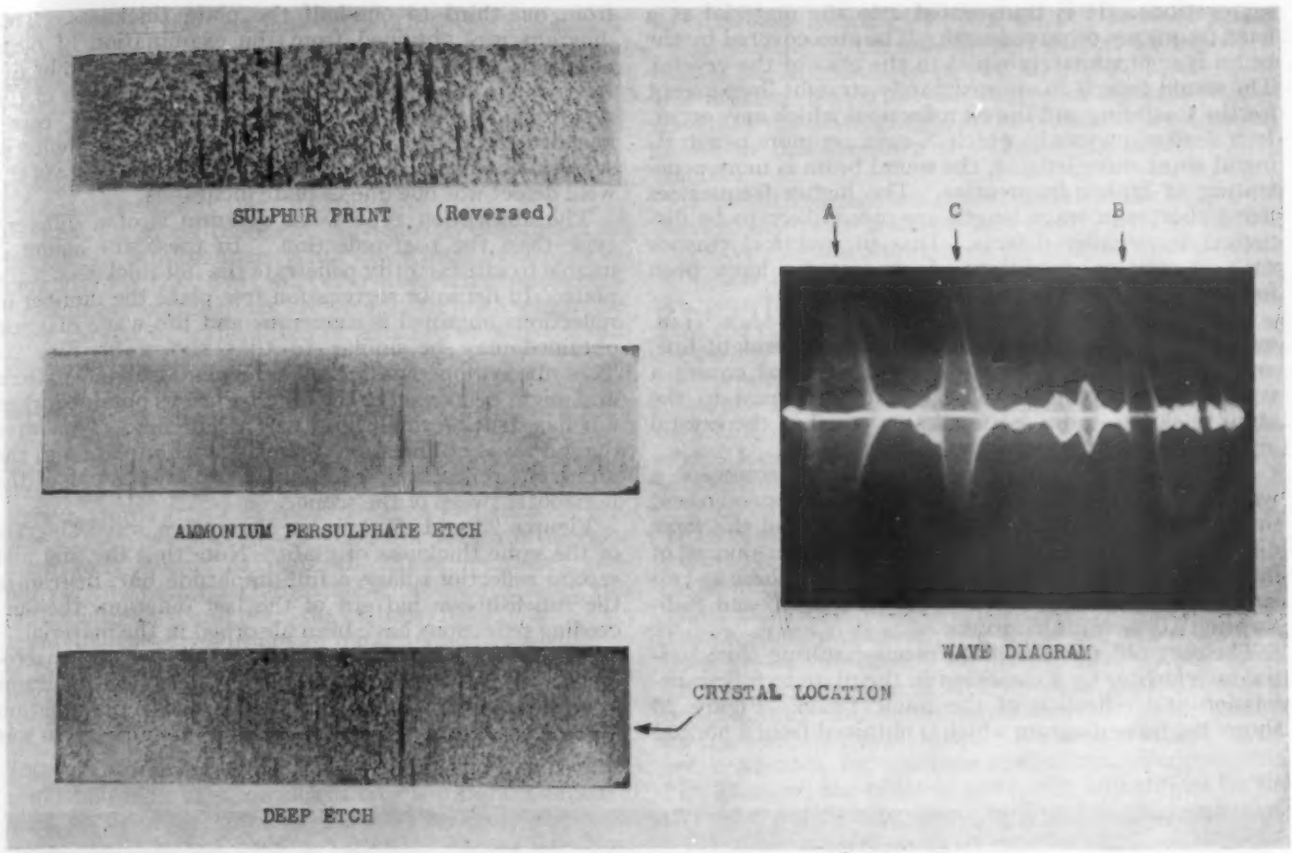


Fig. 32—A Further Study of $4^1/_2$-In. Plate

the material being tested and to measure the length of time required for these to penetrate it, reflect from the opposite side, and return to their starting point. By taking advantage of the facts, that high frequency sound travels in a straight line, that it is reflected or absorbed by certain physical variations in a material, and that it is transmitted at a certain fixed rate, depending upon the material, it is possible to record the action of the sound on an oscilloscope and by a visual observation obtain an indication of the presence and location of a defect.

The instrument consists of the proper high frequency oscillator and amplifier. The oscillator may be tuned over a range of frequencies of from 1 to 11 megacycles. The output of the oscillator circuit is applied to the faces of a quartz crystal ground to a thickness suitable for the frequency desired. A quartz crystal has a piezoelectric property which causes it to "grow" when a difference in electrical potential is applied to its faces. If this voltage is applied at a high frequency the crystal will vibrate accordingly producing high-frequency sound waves. The reverse is also true, that is, when a high-frequency vibration is applied to the crystal a small difference of potential appears on its faces which, if amplified and placed on an oscilloscope, will indicate its response to the vibration. Figure 21 is a photograph of the machine.

Figure 22 will show more clearly what is taking place in a piece of material when the crystal is held in close contact with the surface. At *A* we have the zero sweep line which is notched by inch marks. This is accomplished by a triggering system in the oscillator circuit. At each period of time corresponding to the distance sound will travel in a material in one microsecond the electronic spot generating the sweep line is deflected. This then converts time of travel of sound into measurement of distance.

At *B* in the above diagram is shown the initial reflection or pulse at the face of the material being checked. *C* is the reflection from the opposite face, in this sample $8^1/_2$ in. away. *D* is the reflected vibration from a defect located approximately 4 in. from the face.

The instrument is being used very successfully for testing billets, forgings, shafts and similar objects for defects. A fully laminated plate gives a very clear and accurate indication. For some weld defects it is very satisfactory but, when complete examination of the weld is to be made, obtaining a satisfactory surface condition is a problem. Defects of very small thickness which, for example, are perpendicular to an X-ray beam, such as a tight lamination, flakes, etc., are easily shown. Many other applications may be cited which are of equal importance and for which the instrument gives satisfactory results.

There are certain disadvantages which require experience in operation, prevent some applications, and require skill for interpretation. Surface preparation is usually a problem for surfaces must be reasonably smooth and flat. Oil must be used to assure contact of the crystal to the material so the best position for the work is flat. The wave diagram, while easily interpreted for gross flaws, will require some degree of skill and experience when small defects and conditions are being studied. Curved surfaces cannot be readily examined without grinding crystals to suit.

The sound beam being transmitted into the material has several characteristics which need to be understood in connection with the use of the Reflectoscope for the disclosure of plate conditions such as laminations and

segregations. It is transmitted into the material at a fixed frequency or wave length. The area covered by the beam is approximately equal to the area of the crystal. The sound travels in approximately straight lines except for the scattering and the off reflections which may occur. In a similar manner in which X-rays are more penetrating at short wave lengths, the sound beam is more penetrating at higher frequencies. The higher frequencies being shorter in wave length are more likely to be disturbed by smaller defects. Due to practical reasons such as surface conditions, 5 megacycles have been found the most satifactory for our purpose.

The crystal size used may be one which is $^1/_2$ x $^1/_2$ in. or 1 x 1 in. Since the sound travels in a straight line, an inspection at one location of the crystal covers a volume in the plate which has a depth equal to the plate thickness and a sectional area equal to the crystal area.

We will call the image shown by the Reflectoscope a wave diagram. The different conditions encountered in the inspection of plates gives a variation in the wave diagrams obtained and these require a certain amount of interpretation. We have chosen to classify these as two types which will be called "part-reflection" and "absorption" type wave diagrams.

The part-reflection diagram is one resulting from partial interference by a condition in the plate to full transmission and reflection of the sound beam. Figure 23 shows the wave diagram which is obtained from a normal steel plate. There is no interference shown on the zero sweep line between the locations of the front and back reflections. Compare this with Fig. 24 which shows a part-reflection diagram having two reflections between the face and back reflection. (Note that the third, fourth and fifth reflections may be seen.) The reflections shown indicate the presence of a defect at a location of from one-third to one-half the plate thickness. This diagram was obtained from the examination of plate adjacent to a weld in a drum which was found to be defective by radiographic examination. The depth of the repair made to remove the radiographic defect corresponded to the depth of the defect shown by the Reflectoscope in the plate. Our interpretation of the cause of the weld defect was one due to plate inclusions.

The absorption type wave diagram is of a different type than the part-reflection. In these the sound is unable to satisfactorily penetrate the full thickness of the plate. In dense or segregation free plate the number of reflections obtained is numerous and the wave diagram obtained may be similar to that shown by Fig. 25. This absorption picture has a regular fishbone pattern and might be likened to the reverberations obtained when a bell is struck a single blow with a hammer. This wave diagram was obtained on a relatively thin plate and the numerous reflections are grouped by adjustment of the horizontal sweep of the scope.

Figures 26 and 27 show an absorption wave diagram of the same thickness of plate. Note that the first and second reflections have a full amplitude but, instead of the full fishbone pattern of the last diagram, the succeeding reflections have been absorbed in the material.

At this point it will be of interest to compare macrosections of the plate material from which these diagrams have been obtained. Figure 28 shows at the location marked 6*A*, the area from which the fishbone pattern was

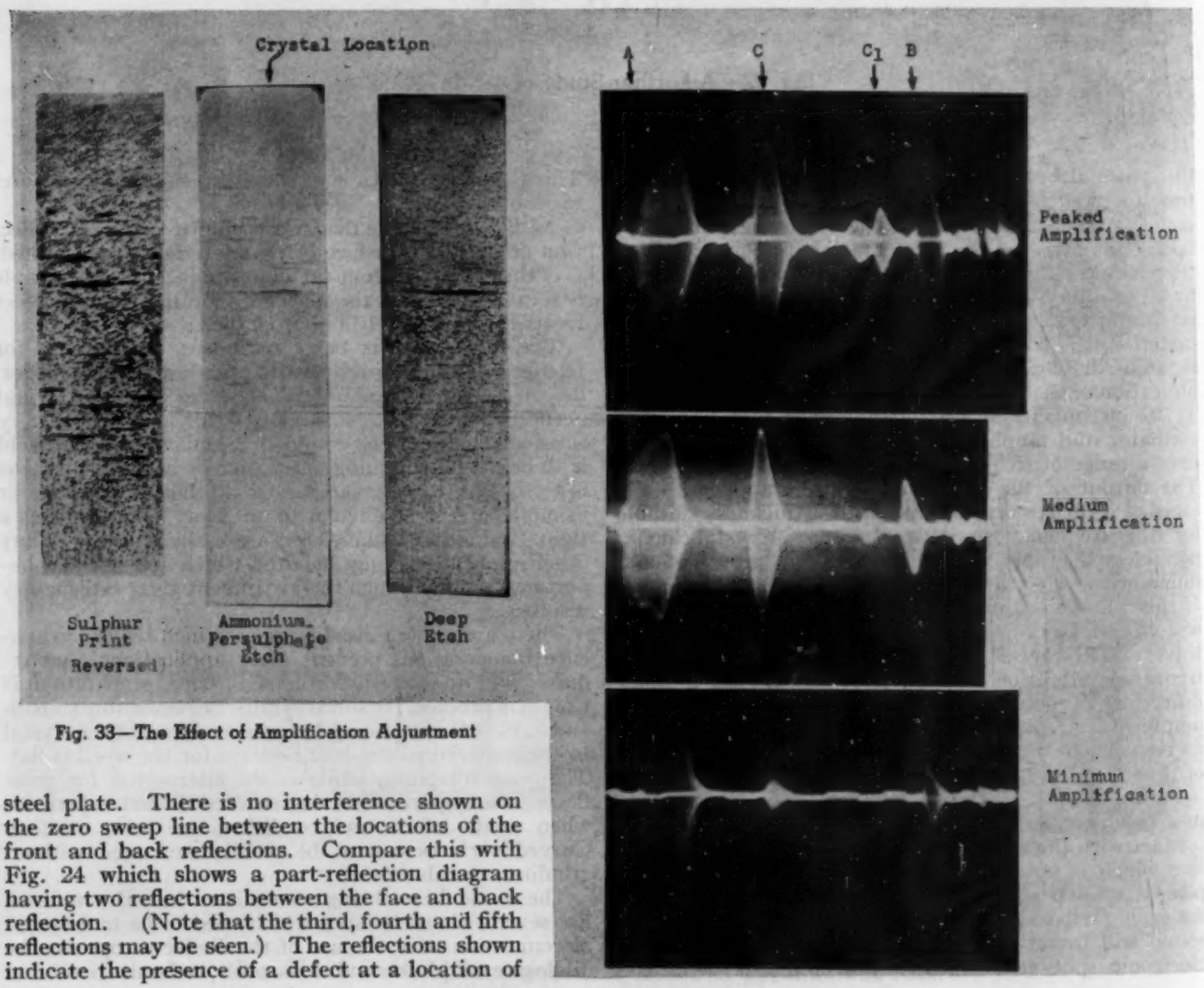


Fig. 33—The Effect of Amplification Adjustment

obtained. At the locations *6B* and *6C* the absorption diagrams were obtained. These macrographs have been lightly etched with ammonium persulphate and although the reason for the absorption difference is difficult to see, close observation of the areas at *B* and *C* shows a more pronounced segregation streak. A sulphur print of these sections showed high concentration of sulphides present at these locations.

These diagrams represent only partial absorption of the beam. Approximately full absorption by a plate is shown by Fig. 29. This will occur when large numbers of inclusions or segregations are present through which the beam cannot be transmitted or reflected or where a full lamination exists in the plate.

Part-reflection and absorption characteristics may be present in the same diagram. Absorption conditions do not necessarily occur only in thin plates but may be seen in thicker ones as well. Normal first reflections and those representing a defect may be present, but the second, third, etc., reflections absent. Whether or not one or both types occur on the same diagram depends upon such factors as plate thickness, frequency employed, the particular adjustment of the machine, the skill of operation and upon the material itself.

Having these conditions in mind a study of a number of plate sections with the Reflectoscope will follow and, by macroexamination, show the degree of segregation which is indicated by this instrument. Figure 30 is a study of a plate which is $1^1/_4$ in. thick. The wave diagram shown as *3A* is the most normal condition which could be found at a low sensitivity setting. The wave diagram *3B* shows a second location taken at the same machine setting but giving a relatively intense reflection type wave diagram as shown at *C*. The macrosection have been etched first by making a sulphur print, then by ammonium persulphate and finally by a hot 1:1 solution of hydrochloric acid. In etching in this manner we had in mind that other inclusions may be present in the material besides sulphides and that this method would give an indication of the over-all condition. These macrographs show a general sulphide condition in the core of the plate with rather heavy inclusions at the one edge corresponding to the wave diagram *B*. Although these macros give some indication that this plate is a rimmed steel, it is S.A. 212 grade silicon-killed steel.

This sample was cut from a plate which gave segregation trouble when welded. It indicates that this type part reflection (note that *3B* has no absorption characteristics) has some significance with respect to what may be expected from this type segregation condition when encountered in arc welding.

Figure 31 shows a similar study of a plate which is 4 in. thick. This section of plate was obtained by trepanning at tube hole locations adjacent to the weld in the drum for which this plate was used. The radiographic examination of the weld revealed numerous defects of the type shown in Fig. 14. These were explored by chipping and were found to be located along the line of fusion in the weld and to extend into the plate in the manner depicted by the macrographs shown above.

The wave diagram Fig. 31 (top right) shows a part-reflection at *C* at about one-third the distance from the crystal location surface. The sulphur print shown is reversed from the etched macrographs since the print is made by direct contact with the specimen. There is no obvious indication by these etchings at the crystal location *A* which accounts for the reflection shown. This is probably due to the region sectioned, having in mind that the sound covers an area through the metal thickness equal to that of the crystal. The wave diagram shown by Fig. 31 (lower right) is much clearer since it shows low-intensity reflections over most of the zero sweep line such as are indicated by *C1* in this same diagram.

The location of the radiographic defects correspond to that of the reflection shown at *C* on the diagrams. This will indicate that a certain degree of segregation, not shown by the macrographs of the particular location sectioned in this specimen is necessary to cause welding troubles.

How much segregation caused trouble in the arc-welded seam in this plate is shown very clearly by Fig. 32. In the wave diagram shown here the reflected wave shown at *C* has its origin at approximately one-third of the specimen thickness from the face of the crystal location. This corresponds to a very definite segregation streak as shown by the macroetched section. The reflections shown between *B* and *C* on the wave diagram are those caused by the bands of segregations located at the region one-third of the thickness from the face opposite the crystal location. (Note that these areas are shown in the sulphur print above.)

The locations shown by the wave diagrams and the segregation streaks shown by the macroetching corresponded exactly to those at which the trouble was found in the weld when this was explored by chipping.

Our experience with the Reflectoscope so far indicates it is possible to disclose plate conditions which we have been unable to classify by any other method tried. There is a good deal of additional information needed before a fully satisfactory application of the instrument for this purpose can be made. We must establish standard conditions for machine sensitivity. For example, Fig. 33 shows the effect of sensitivity adjustment on the pickup of the defects shown by Fig. 32. By an adjustment of the amplification of the machine the characteristics of the wave diagram change considerably. At peaked amplification the diagram shows a defect at *C* and *C*1 and a number of additional reflections very plainly. The medium amplification setting shows approximately the same results as the peaked except you will note that the defect at *C* shows with equal amplitude whereas the back reflection *B* and the second defect reflection C1 have lost considerable intensity. This is due to the absorption by the defect at *C* of a large portion of the beams intensity. At minimum amplification all is lost excepting a small indication of the first or *C* defect.

Several conclusions may be drawn from this. First, our experience in welding this plate showed that the defect at *C* and *C1* caused radiographic defects. Second, that small amounts of inclusions well scattered as represented by the section shown between *C* and *C1* do not normally cause trouble. If this is true, then a setting of this instrument on medium sensitivity and an examination of the plate from both sides will indicate the presence of plate segregations or inclusions which may give trouble in welding.

Summary

1. Radiographic testing technique used today gives better results than earlier methods and at least one-half of 1% sensitivity may be expected under proper conditions.

2. Welding methods and our understanding of welding problems have so improved pressure vessel welding that gross defects in welds such as slag and porosity are today relatively uncommon.

3. The most troublesome type defect found in arc welds of pressure vessels today is one resulting from plate conditions which may be called segregations or inclusions and which contain sulphides. The encountering of these by the welding arc and the heat of welding re-

sults in serious defects along the line of fusion of the welds. These are disclosed by radiographic testing.

4. A long search for methods for determination of plate quality with respect to the segregation condition described has not given results until the recently developed Reflectoscope became available.

5. The Reflectoscope gives promise of providing a nondestructive means for studying plates along their welding edges prior to welding and making possible a selection of those which will weld satisfactorily because of the presence of an allowable distribution of segregations and inclusions.

6. Much work remains to be done in the study of the Reflectoscope for this application. Results so far indicate that for plates of thicknesses in excess of $1^1/_4$ in. the wave diagrams obtained may easily be classified as ones resulting from segregations which will or will not cause trouble in welding. Thinner plates require more study and work now under way will indicate what success may be expected in this range of thickness.

Current Welding Literature

Airplane Engine Manufacture. Welding Turbo-Jet Engines, W. J. Campbell. Welding Engr., vol. 31, no. 3 (Mar. 1946), pp. 33–35.

Automobile Engines, Crosley. Brazed Sheet Metal Automobile Engine. Sheet Metal Industries, vol. 23, no. 227 (Mar. 1946), pp. 533, 536.

Automobile Manufacture. Brazed Stampings Basis of New Auto Engine, H. A. Knight. Matls. & Methods, vol. 23, no. 2 (Feb. 1946), pp. 438–440.

Brazing, Electric. Tool Tips Induction Brazed, T. A. Vernor and E. F. Adams. Welding Engr., vol. 31, no. 3 (Mar. 1946), p. 53.

Brazing, Silver Alloys. Application of High Frequency Heating to Silver Brazing and Silver Soldering, H. A. Folgner. Western Metals, vol. 4, no. 3 (Mar. 1946), pp. 35–37.

Brazing, Silver Alloys. Filler Metal Flow in Brazed Steel Joints. Iron Age, vol. 157, no. 15 (Apr. 11, 1946), pp. 60–61.

Brazing, Silver Alloys. Production Methods by Silver Brazing, R. H. Ruud. Machy. (Lond.), vol. 68, no. 1743 (Mar. 7, 1946), pp. 297–303.

Bridges, Steel Truss. 438 Ft. Span Welded Truss for Hawkesbury River Road Bridge, V. Karmalsky. Instn. Engrs. Australia —J., vol. 17, nos. 10–12 (Oct.–Dec. 1945), pp. 225–227.

Clamping Devices, Pneumatic. New Development in Work Holding, R. M. Hays. Western Machy. & Steel World, vol. 37, no. 3 (Mar. 1946), pp. 122–123, 136.

Cutting Tools, Brazing. Automatic Induction Brazing Speeds Tool Tipping. Iron Age, vol. 157, no. 15 (Apr. 11, 1946), pp. 54–55; see also Machy. (N. Y.), vol. 52, no. 8 (Apr. 1946), pp. 177–178.

Electric Welding, Arc. Heliarc Welding of Magnesium. Modern Metals, vol. 11, no. 2 (Mar. 1946), pp. 17–18.

Electric Welding, Arc. Helium Arc Welding. Industry & Welding, vol. 19, no. 3 (Mar. 1946), pp. 44–46.

Electric Welding, Arc, Tire Molds. Redesign for Welding Saves 50%. Industry & Welding, vol. 19, no. 3 (Mar. 1946), pp. 61, 96–97.

Electric Welding, Electrodes. Manufacture of Welding Electrodes. Machy. (N. Y.), vol. 52, no. 8 (Apr. 1946), pp. 152–155.

Electric Welding Machines. Arcwelding Equipment in Wartime Germany, F. W. Myers, Jr. Iron Age, vol. 157, no. 17 (Apr. 25, 1946), pp. 46–50.

Electric Welding, Resistance. Application of Electronic Control to Bench Welders, L. J. Gootschalk, Jr. Machy. (Lond.), vol. 68, no. 1744 (Mar. 14, 1946), pp. 335–338.

Electric Welding. Resistance Welding for Sheet Metal Shops, H. S. Card. Sheet Metal Worker, vol. 37, no. 2 (Feb. 1946), pp. 44–46, 52.

Iron Castings. Gray Iron Castings—Welding and Salvage, J. A. Griffin. Am. Foundryman, vol. 9, no. 3 (Mar. 1946), pp. 16–23.

Iron Castings. Welding Malleable Cast Iron, M. N. Vuchnich. Welding Engr., vol. 31, no. 3 (Mar. 1946), pp. 58–59.

Jigs and Fixtures. Hard Facing Work Positioner. Iron Age, vol. 157, no. 14 (Apr. 4, 1946), p. 79.

Locomotive Maintenance and Repair. New Tasks for Welding Torches, A. Havens. Welding Engr., vol. 31, no. 3 (Mar. 1946), pp. 46–48.

Magnesium. Welding Magnesium, M. M. Moyle. Western Machy. & Steel World, vol. 37, no. 3 (Mar. 1946), pp. 110–113, 136.

Metallurgy, Fluxes. Slags and Fluxes, H. Lepp. Metal Industry, vol. 68, no. 11 (Mar. 15, 1946), pp. 203–205; no. 12 (Mar. 22), pp. 227–228.

Metallurgy. There Is Difference in Metallurgy, V. E. DeStrasser. Industry & Welding, vol. 19, no. 2 (Feb. 1946), pp. 47–50; (Mar.), pp. 64–67, 97, 99.

Oxyacetylene Cutting, Accident Prevention. In Scrapping Our Ships Never Scrap Safety, W. R. Stewart. Safety Eng., vol. 91, no. 1 (Jan. 1946), pp. 20–21.

Petroleum Products Pipe Lines, English Channel. Operation Pluto: Hamel Steel Pipe line, J. S. Blair. Inst. Welding—Trans., vol. 9, no. 1 (Feb. 1946), pp. 14–19.

Petroleum Refineries, Equipment. Nickel-Lined Pressure Vessel, D. E. Evans and W. B. Meyer. Welding Engr., vol. 31, no. 3 (Mar. 1946), pp. 38–40.

Petroleum Refineries, Stainless Steel. New Type Chromium-Nickel Alloy Offers Wider Range of Refinery Applications, J. S. Ewing. Nat. Petroleum News, vol. 38, no. 14 (Apr. 3, 1946) (Sec. 2), pp. R243–R246.

Piers, Military. "Whale" Piers for Mulberry, A. Lamonde and R. G. Braithwaite. Welding Engr., vol. 31, no. 3 (Mar. 1946), pp. 49–52.

Product Design. Parts and Metal-Forms, F. P. Peters. Matls. & Methods, vol. 23, no. 1 (Jan. 1946), pp. 101–104.

Road Machinery. Maintenance of Contracting Equipment, R. A. Brady. Industry & Welding, vol. 19, no. 3 (Mar. 1946), pp. 42–43, 85.

Road Machinery. Welding Design and Fabrication of Road Building Machinery, W. Richards. Industry & Welding, vol. 19, no. 3 (Mar. 1946), pp. 38–41.

Shipbuilding. All-Welded Destroyers. Shipbldg. & Shipg. Rec., vol. 67, no. 12 (Mar. 21, 1946), pp. 320–323.

Shipbuilding. Recent Advances in Welding Applied to Shipbuilding, D. M. Kerr. Inst. Welding—Trans., vol. 9, no. 1 (Feb. 1946), pp. 29–43.

Shipbuilding. Shipyard for Welded Construction, R. F. Grambow. Mar. Eng. & Shipg. Rev., vol. 51, no. 3 (Mar. 1946), pp. 102–108, 164.

Shipbuilding. Vee-Type Butt Welds in Mild-Steel Plating. Shipbldr. & Mar. Engine-Bldr., vol. 53, no. 444 (Mar. 1946), pp. 128–130.

Stainless Steel. Notes on Welding Stainless Steel, H. A. Campbell. Western Metals, vol. 4, no. 2 (Feb. 1946), pp. 17–19.

Steel Hardening, Oxy-Gas Process. Flame-Hardening Set-Up for Small Machined Parts. Western Machy. & Steel World, vol. 37, no. 3 (Mar. 1946), pp. 128–129.

Steel Heat Treatment. Effect of Stabilizing; and Stress Relief Heat Treatment Upon Welded 18-8 Stainless Steel, W. G. Hubbell. Steel Processing, vol. 32, no. 3 (Mar. 1946), pp. 181–186.

Steel, Weldability. Metallurgical Features in Welded Steels, H. O'Neill. Inst. Welding—Trans., vol. 9, no. 1 (Feb. 1946), pp. 3–9.

Tanks. Welded Tanks for Chemical Process Industries, C. E. Heil. Industry & Welding, vol. 19, no. 3 (Mar. 1946), pp. 52–56.

Tube Mills. Electrically Welded Tubes, J. Lucas. Iron & Coal Trades Rev., vol. 152, no. 4073 (Mar. 22, 1946), pp. 533–534.

Water Pipe Lines, Maintenance and Repair. New Method for Cutting Cast-Iron Pipe, W. R. LaDuc. Am. Water Works Assn.—J., vol. 38, no. 3 (Mar. 1946), pp. 345–347.

Water Pipe Lines. Tentative Standard Specifications for Field Welding of Steel Water Pipe Joints. Am. Water Works Assn.—J., vol. 38, no. 3 (Mar. 1946), pp. 391–400.

Welding. Causes and Prevention of Defects in Welding, F. S. Dever. Western Machy. & Steel World, vol. 37, no. 3 (Mar. 1946), pp. 118–121, 138–139.

Welding. Iron Age, vol. 157, no. 14 (Apr. 4, 1946), pp. 87–90.

Welding, Joining, Fastening, T. C. DuMond. Matls. & Methods, vol. 23, no. 1 (Jan. 1946), pp. 135–139.

Welding Shops. Mobile Welding with Royal Engineers, R. B. Croft and O. Lithgow. Inst. Welding—Trans., vol. 9, no. 1 (Feb. 1946), pp. 10–13.

Welds, Inspection. Magnetic Inspection of Welds, G. C. Close. Steel Processing, vol. 32, no. 2 (Feb. 1946), pp. 122–127.

Welds, Testing. High-Strength Pressure Welded Joints, C. B. Voldrich and J. L. Zambrow. Steel, vol. 118, no. 15 (Apr. 15, 1946), pp. 98–99, 136, 138, 140–142, 144.

Welds, X-Ray Analysis. Testing of Welds in Holland. Inst. Welding—Trans., vol. 9, no. 1 (Feb. 1946), pp. 2, 13.

X-Ray Analysis. Radiography. Am. Soc. Testing Matls.—Standard (1945 Supp.), pt. 1, 1945, p. 380.

Changeover of a Band Saw to Welded Design

By J. R. Morrill*

THE former design of a metal-working band saw used for applications such as die cutting is shown in Fig. 1. The frame, doors and guards were made of cast iron, with a total weight of 1150 lb. (excluding motor and other electrical equipment). Due to the difficulty in obtaining castings and due to the high cost of pattern changes when a new model was designed, Grob Brothers of Grafton, Wis., manufacturers of the product, studied the possibilities of welded design. This led them to manufacture the machine by arc welding.

The design and fabrication of this modern machine by arc welding illustrate well the advantages inherent in arc-welded fabrication, i.e., simplicity, rigidity and flexibility. These advantages have resulted in better appearance, less weight and low cost.

Figure 2 shows the finished product of welded design. This band saw has a much greater capacity than the former design and weighs only 900 lb. If cast iron were used, the weight of this larger unit would be about 1400 lb. Hence, welded design has saved about 500 lb. The new arc-welded machine sells now for $235, whereas the old machine (Fig. 1), of less capacity and more weight, sold for nearly double this amount. (Price does not include motor and controls.)

The entire frame is made of 10-gage (0.1345-in.) steel. The cast machine frame material averaged $^{5}/_{16}$ in. in thickness. Hence, a saving over-all of slightly less than $^{3}/_{16}$ in. is effected through the use of steel. Ten gage material has marked advantages over other material thicknesses that could be used for welding of the bandsaw, permitting the use of square edge butt joints, which require a minimum of joint preparation and allow maximum welding speed when welded in the flat position.

The steel stock is accurately formed and clamped for tack welding so that practically no machining is necessary on the welded frame. The front and back views in Figs. 3 and 4 show how extensively forming is used to minimize welds. Total length of welds in the frame is about 450 in.

The frame column is designed so that one-half can be welded along the entire length of the machine. A seam of 78 in. is continuously arc welded with the automatic machine as shown in Fig. 5. Actual arc time for making this weld manually was 6 min., whereas for the automatic welding it takes only 1 min. Also, 3 min. are saved through the elimination of slag removal and grinding, for the surface of the automatic weld is smooth and uniform, the slag dropping off. Since the arc is completely contained beneath the flux, there is no spatter to be cleaned off before painting. Many more welds could probably be made automatically if the frame were placed on a positioner so as to quickly manipulate it under the automatic welding head.

This application illustrates an opportunity for cost reduction in many products. Designers can effect added savings over those already effected through manual arc welding by thinking in terms of automatic arc welding. The automatic process eliminates spatter, slag removal, grinding, and it permits heavier square edge butt joints (which cut preparation costs) to be joined.

One of the chief advantages of the welded design is that it eliminates machining. Many of the holes, formerly drilled, are now punched.

The completed welded frame shown in Fig. 5 weighs approximately 325 lb. Production cost is about $38 without doors. This amounts to about twelve cents per pound. A casting for the same capacity machine would weight about 800 lb. and would cost more than $80.

Fig. 1

Fig. 2

* Assistant to the Vice-President, The Lincoln Electric Co.

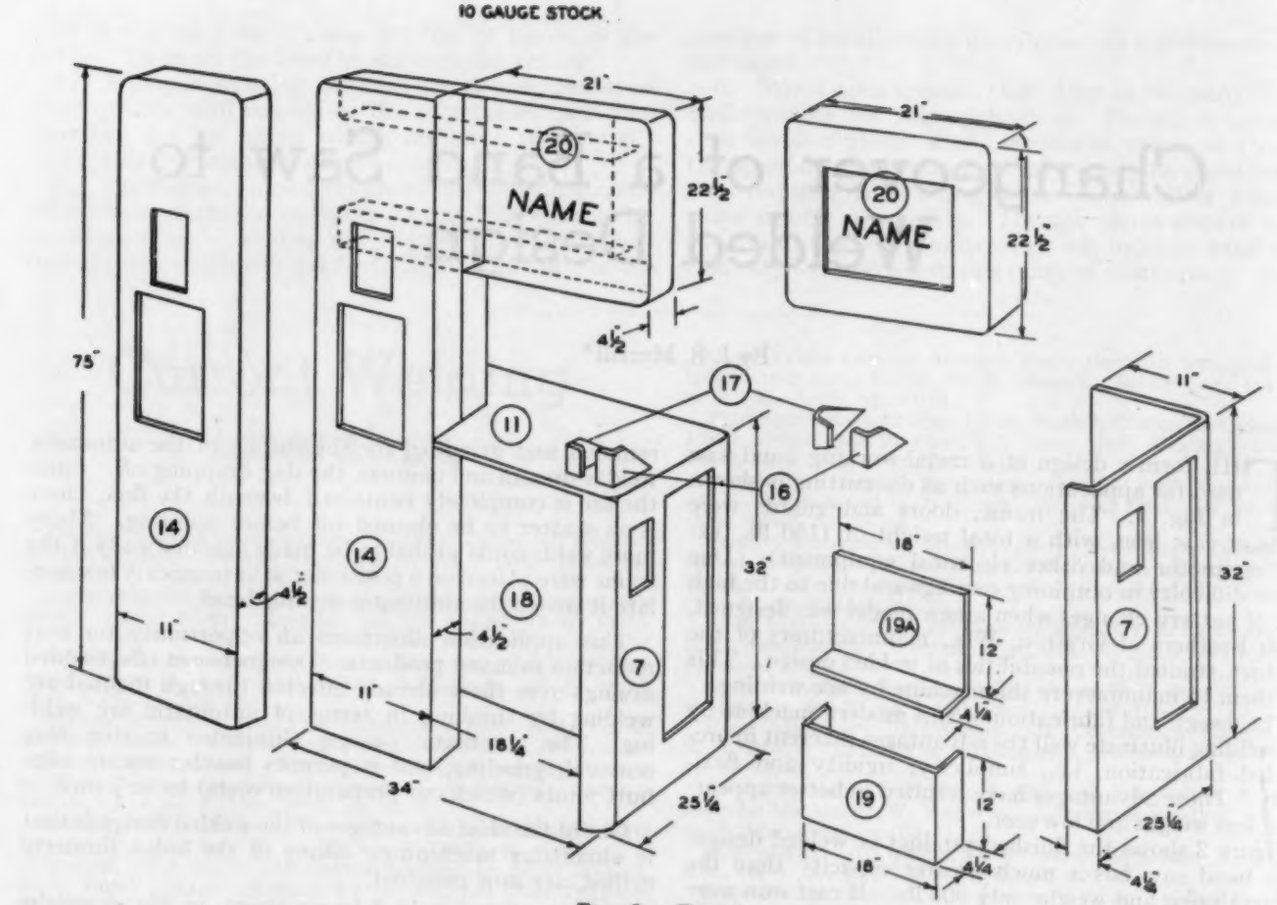


Fig. 3 (Front)

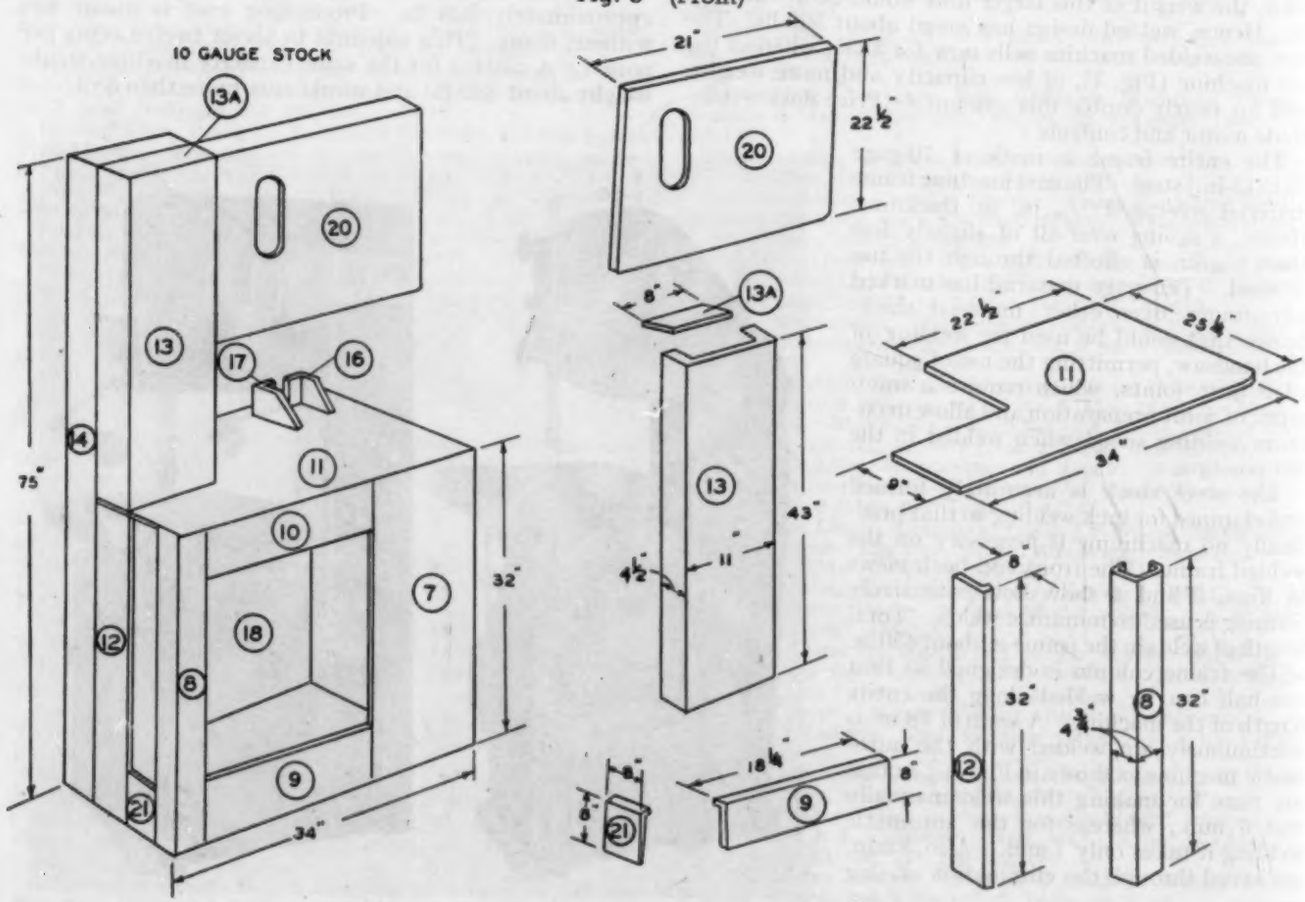


Fig 4 (Back)

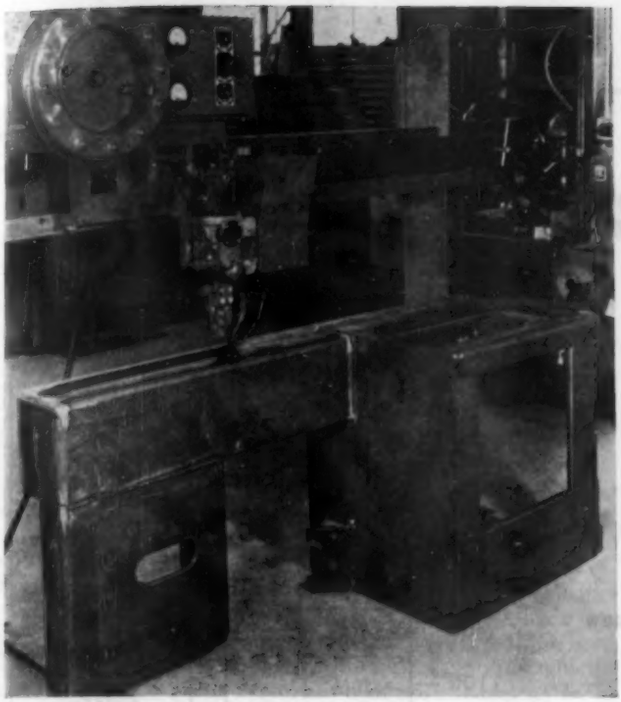


Fig. 5

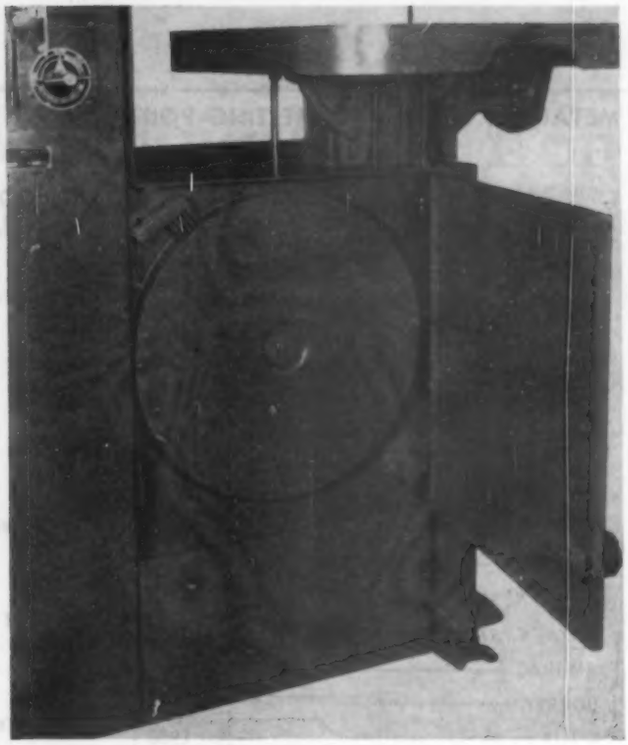


Fig. 6

Procedure

Refer to Figs. 3, 4 and 5 for the design of the component parts and location of welded joints. Where possible, corners and section changes are made by bending the sheet metal, with the bends selected along the longest axes to minimize welding. The door openings (Fig. 5) are reinforced by using a blank and form die, thus forming the edges in the same operation as blanking. An attractive name plate is formed by means of a die impression while the cover for the head is formed. In Fig. 3, piece number 18 is welded in to form the tight compartment shown in Fig. 6. This prevents steel chips from flying into the motor mounted on the other side of the base. Pieces 19 and 19-A form a chip disposal container which is readily removable.

This design illustrates the freedom which the designer has in placing metal for maximum advantage to meet functional requirements. No allowance is necessary for extra wall thickness or special contours to conform with metal-pouring requirements of a casting.

By forgetting the old construction, the designer can achieve a highly functional frame with streamlined appearance at low cost.

The manufacturer sums up the advantages of welded design in his case by stating that "for less money a larger capacity machine is produced having a neater, more streamlined appearance. The cost saving is passed on to the customer as a drastic price reduction."

Melting Points of Metals and Alloys

By H. R. Morrison*

THE melting points of those metals and alloys that have a melting-point range narrow enough to be considered a single temperature are given in the left-hand column of the chart on the next page. The melting points of various alloys having a wider range appear in the right-hand column. The color scale in the center shows the approximate temperatures at which color changes appear. The right-hand column with both centigrade and Fahrenheit scales can be used as a general conversion table between these scales. An accurate conversion can be obtained from the formulas:

$$^\circ \text{F.} = 9/5 \times {}^\circ \text{C.} + 32$$

and

$$^\circ \text{C.} = 5/9 \times (^\circ \text{F.} - 32)$$

Degrees centigrade can be converted to degrees Fahrenheit easily by mental arithmetic. Simply multiply the centigrade temperature by 2, subtract 10% and add 32. For example, 640° C. times 2 equals 1280; minus 10% equals 1152; plus 32 equals 1184° F. For rough estimating purposes, 640° C. times 2 equals about 1300; minus 10% equals about 1170; plus 32 equals about 1200° F.

The color scale is purposely indefinite as to the border lines between the colors, because of the difference of opinion as to color names, and because the amount of light present affects the color seen. The colors for the temperatures indicated can be seen only in a dark location. In a well-lighted shop, faint red may not appear until the metal had reached a temperature of 1100 or 1150° F.

* The Linde Air Products Company, New York.

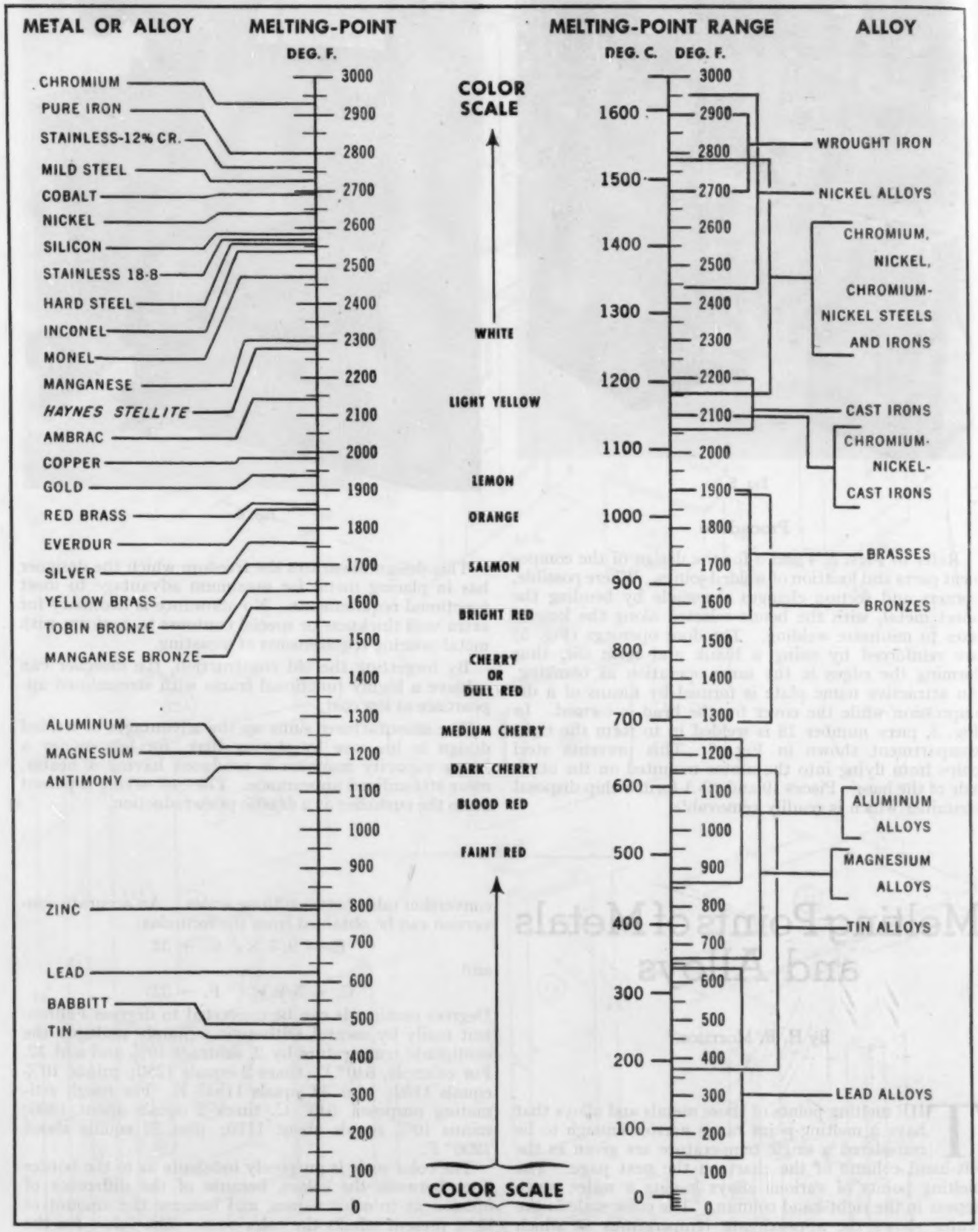


Chart Showing Temperature Data of Metals and Alloys

Procedures for Arc Welding Gray Iron Castings

By C. E. Phillips*

ALTHOUGH the variety of practical and economical applications of the metallic arc welding process to the salvage of defective, worn or broken gray iron castings is very large, this does not mean that every new job presents an entirely different problem. Long experience in this field of reclamation welding has shown that most jobs can be quickly identified as belonging to a certain group and that the correct procedures for all jobs in any group will differ only in certain details.

One general classification includes castings which require building up with additional metal in certain areas. These jobs can be subdivided into typical groups which, in turn, require (1) a restoration of lost metal as in a broken gear tooth, (2) the filling of a cavity as in a porous or defective casting, (3) building up a surface which has been worn away or incorrectly machined or (4) putting on metal to accommodate a change in design. These are some of the most frequently encountered build-up jobs; there are, of course, many others.

An important common factor in all of these build-up operations is the need for avoiding hardness in the deposited metal, in the line of fusion and in the heat-affected zone of the parent metal. Many so-called failures have been reported, even when the correct electrode material has been used, and investigation has usually disclosed that these failures were caused by lack of any effort to make the deposit in such a manner as to preserve the full machinability of the casting. In other words, the chief difficulty encountered has been the development of hard spots because of not using the correct procedure.

* President, C. E. Phillips & Co., Detroit 8, Mich.

Fig. 1—Casting with Cavity Filled by Arc Welding

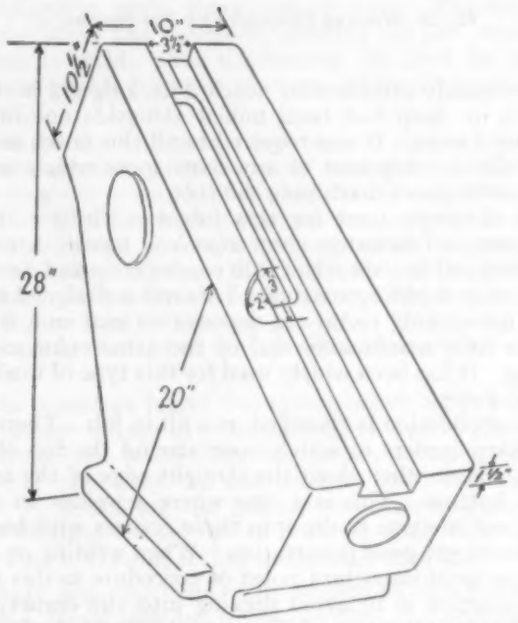


Fig. 2—Principal Dimensions of Casting and Cavity

The experienced arc welder working on ordinary steel usually "digs in" or tries to get good penetration and, at the same time, uses as large an electrode as the work will stand, in order to reduce welding time. Such arc welding procedure will not produce machinable deposits on gray iron castings, because it overheats the metal so that it is easily chilled and also allows the deposited metal to pick up impurities from the parent metal. Chilling of the overheated castings, of course, results in the formation of hard carbides, which give trouble in machining. A go welding operator working with any good material can usually avoid porosity and checking in the deposit. Therefore, the thing he has to learn for the correct building up on cast iron is to avoid chilling, and thus to produce a fully machinable deposit, provided that he uses electrode material which makes that result possible.

A specific case, in which it was necessary to watch the effect of the heat on the parent metal, is illustrated in Fig. 1. This is a job which could be done in two different ways according to the position of the work. The dimensions of the casting and the location of the weld are shown in Fig. 2. The casting weighed about 500 lb., and an

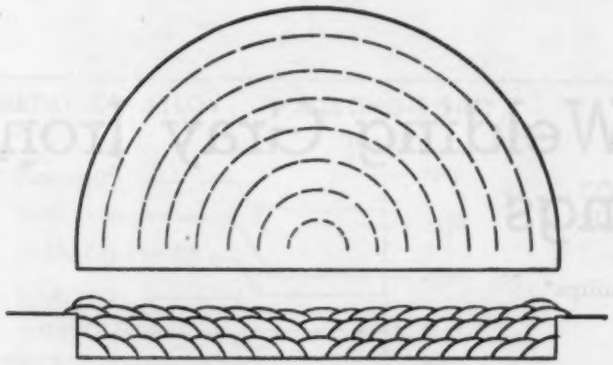


Fig. 3—Welding Procedure for Flat Position

approximately semicircular notch 3 in. long x 2 in. wide and $^3/_8$ in. deep had been milled alongside one of the machined ways. It was required to fill this notch and to avoid the development of any hard spots which would make subsequent machining difficult.

The electrode used for this job was Phillips "600" Electrode, a fabricated nonferrous rod having a nickel core wrapped in a sheath of thin copper strip and covered with a slag shielding coating. This rod is designed especially for making metal arc deposits on cast iron which will be fully machinable and of the same color as the casting. It has been widely used for this type of work for several years.

The application is classified as a fill-in job. There are two sharp corners to watch—one around the top of the notch, and another along the straight edge of the notch at the bottom. This is a case where a welder on steel would not hesitate to dig into these corners with his arc in order to get good penetration. When welding on cast iron, the most important point of procedure in this type of application is to avoid digging into the corner, because hard spots due to chilling are certain to result.

If this cavity were to be welded in the flat position, the procedure would be as follows:

1. Start the first bead on the inside of the corner; that is, at the root of the angle. The starting point should be $^1/_8$ or $^3/_{16}$ in. away from the edge, so as not to melt the edge, and the deposit is carried around the root of the angle to within about $^1/_8$ in. of the other end (see Fig. 3).
2. Clean all slag from the first bead.
3. Apply second bead inside the first, as shown in Fig. 3, holding the arc on the first bead so that about 75% of the heat is applied to the previous deposit and only about 25% affects the parent metal. This procedure avoids both porosity and hardness.
4. Clean all slag from the second bead and repeat until one layer of beads has been laid over the bottom of the cavity.

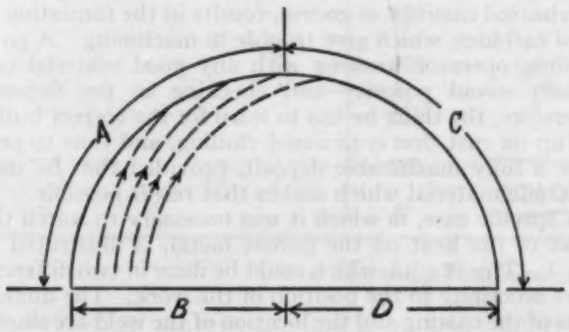


Fig. 4—Procedure Followed for Welding in Inclined Position

5. The metal at the edge will now be warm enough to remove danger of chilling, so that the final bottom bead can be laid along the edge, again holding the arc mostly on the deposited metal instead of allowing it to play on the sharp edge.

The second layer, and other layers to fill, can be deposited with the same procedure. The welding is finished by depositing one bead around the top, holding the arc entirely on the previously deposited metal, and not allowing the deposit to flow over onto the parent metal. This final bead has an annealing effect on the parent metal near the edge and also insures having sufficient build-up so that the casting will machine perfectly.

Actually, the above procedure was not followed in the case illustrated, because it was considered that it would take longer to set the casting in position for flat welding than it would to weld it in the inclined position by following a slightly different procedure. With the work in the inclined position, welding was started in the lower corner and $^1/_8$ in. from the edge. The first bead was carried only part way around the arc of the cavity. Three additional beads of about the same length were deposited. Figure 4 indicates at *A* the approximate length of these deposits, and Fig. 5 shows how the beads overlapped. In the case of each bead after the first, the arc was always held largely on the previous deposit, and care

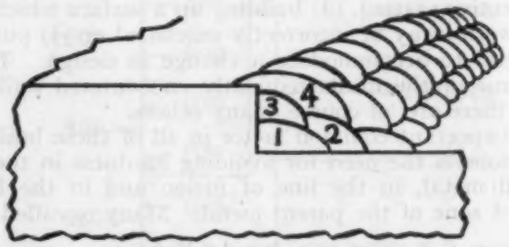


Fig. 5—Section of Bead Deposits, Showing How Breakdown of Sharp Corners Was Avoided

was always taken to thoroughly clean away the slag from each bead before depositing the next one. By this time, there was a shoulder formed on which additional beads were deposited to build up slightly above the original level.

When the cavity was about half filled, the edge was warmed sufficiently so that beads could be deposited along the area indicated at *B* in Fig. 4, without danger of chilling. The upper half of the cavity (Fig. 4 (*C*)) was filled in the same manner, finishing with a deposit along the edge at *D* in Fig. 4. One final bead was then deposited around the edge of the cavity to provide plenty of material for machining. This appears in Fig. 1 as a narrow ridge around the contour of the cavity.

The precautions observed in carrying out this procedure were:

1. To clean out slag thoroughly between deposits.
2. To hold the arc mostly on the deposited metal.
3. To avoid letting the arc play on sharp corners.

By following this procedure, it was possible to make this repair without preheating, which might have warped the casting. The job machined perfectly without encountering hard spots or porosity. In conclusion, it might be pointed out that the details of procedure are based upon the known effects of heating on gray iron castings, and on the necessity for keeping the work clean when it is desired to produce a deposit which will be clean and sound.

Welding of Magnesium

By LeRoy F. Pearsall*

AT the end of the war, the White Aircraft Corp. entered into a new field of welding and fabricating—the welding and fabricating of magnesium. This being an entirely different metal than any welded or fabricated by the White Aircraft Corp. previously, we immediately requested information from the various experts in this field and after various methods of welding had been suggested, we chose the high-frequency a.-c. Argon method.

A large number of welders were trained, and after their training period was over they were tested and approved by the United States Army Air Forces.

In the course of the training and later in production, it was noticed that a terrific amount of work was rejected by our Inspection Department because of burned marks upon either side of the welds. These burned spots made small cracks and craters in the metal. Upon investigation it was found that these burned spots were caused by the high-frequency arc. Due to the ionizing action of the Argon gas, the arc could not be stopped soon enough to prevent the high-frequency arc from jumping to either side of the weld when the operator stopped welding. This same condition existed at the start of all welds, particularly if the tungsten electrode was hot. A high-frequency arc would start from a distance of $1/2$ in. from the work. This long arc was just as apt to jump to the welding rod held in the operator's hand, causing the operator to get an electric shock which made it almost impossible to keep the operators working. This condition had to be overcome. The manufacturers of the welding machines and the torches were consulted, with no one being able to give any satisfactory results.

* Supervisor of Welding, White Aircraft Corp.

The White Aircraft Corp.'s chief electrician was asked if he could make up a switch that would turn the high-frequency current and the welding current on and off simultaneously in conjunction with our own foot and hand switches.

A 40-amp. magnetic switch was tied into the line side of the welding machine, operated by a hand or foot switch which enabled the operator to rest the electrode on the place where the weld should start, get welding rod ready and drop face shield. Then when the foot or the hand switch was depressed, the high-frequency current and welding current started simultaneously. The electrode did not stick to the work because with the electrode touching the work, there was no heat. The operator merely lifted the electrode, starting an arc, and proceeded to weld; thus eliminating the need for strong lights to enable the operator to see where the arc must be struck.

Due to the high-frequency current and the welding current starting simultaneously and the fact that the electrode was down to the work as the current started, the possibility of the high-frequency arc jumping to either side of the weld no longer existed; thus eliminating the burned spots entirely. When the end of the weld was reached, the operator merely released the foot or hand switch, instantly stopping the arc; thus once again eliminating the burned spots and the chance of an electric shock.

The operators found this arrangement much easier to use—easier on the eyes because there was no chance of getting a flash while their face shields were up, less tiresome because they did not have to constantly concentrate upon holding the heli-arc torch at just the right spot to start a weld before lowering their face shields, and then wondering if they had moved their hands.

There were no longer any rejections due to the arc blow. The cracks due to the arc blow had been entirely eliminated, and the appearance of the weld had improved immeasurably.

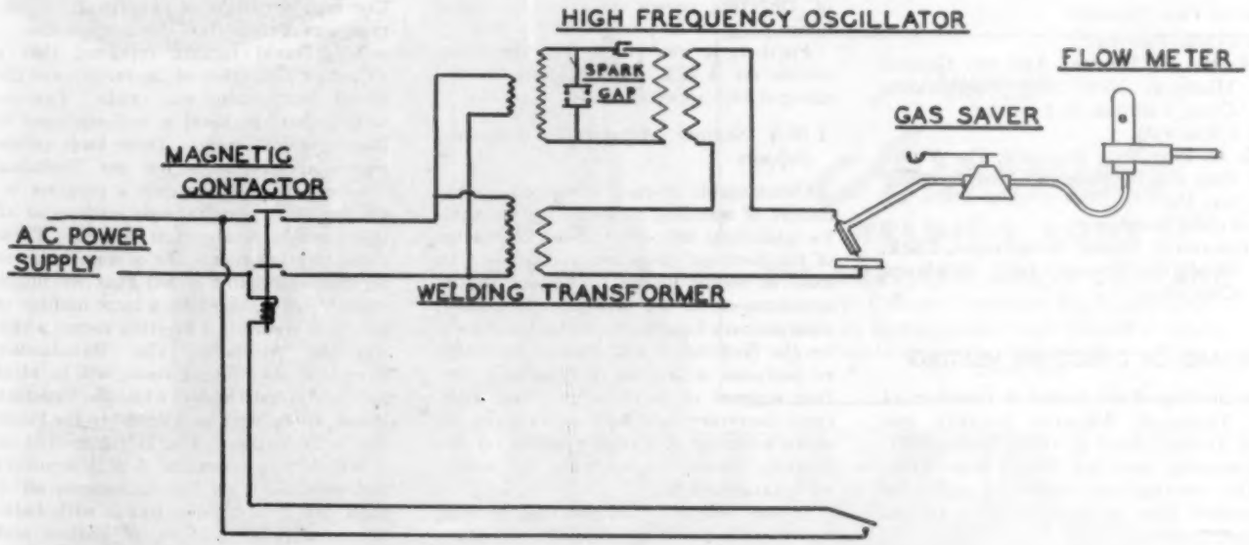


Fig. 1—Diagrammatic Illustration of Connections

THE AMERICAN WELDING SOCIETY

ACTIVITIES — RELATED EVENTS

1946–47 NOMINATIONS

The National and District Nominating Committees have announced the following nominations for National Officers and Directors of the AMERICAN WELDING SOCIETY. These nominations have been submitted to the membership for letter ballot vote.

President—L. W. DELHI, Vice-President, Hunt, Mirk & Co., 141 Second St., San Francisco, Calif.

First Vice-President—HAROLD O. HILL, Asst. Chief Engineer, Fabricated Steel Construction, Bethlehem, Pa.

Second Vice-President—G. N. SIEGER, Pres. & Genl. Mgr., S-M-S Corp., 1165 Harper Ave., Detroit, Mich.

Directors at Large (to serve for 3 years)—

D. H. COREY, Welding Engineer, The Detroit Edison Co., 2000—2nd Ave., Detroit, Mich.

J. F. MAINE, Chief Engineer, Republic Structural Iron Works Co., Cleveland, Ohio.

E. L. MATHY, Exec. Vice-President, Victor Equipment Co., 844 Folsom St., San Francisco, Calif.

LESLIE S. MCPHEE, Welding Supt., Whiting Corp., 157th St. & Cathrop Ave., Harvey, Ill.

District Vice-Presidents

No. 2 (Mid-Eastern):

HARRY W. PIERCE, Asst. to General Manager, New York Shipbuilding Corp., Camden, N. J.

No. 4 (Central):

G. O. HOGLUND, Engineer, The Aluminum Co. of America, New Kensington, Pa.

No. 6 (Mid-Southern):

HOWARD N. SIMMS, Metallurgist, Black, Sivalls & Bryson, Inc., Oklahoma City, Okla.

BOARD OF DIRECTORS MEETING

A meeting of the Board of Directors of the AMERICAN WELDING SOCIETY was held Friday, April 5, 1946, Room 1101, Engineering Societies Bldg., New York.

The meeting was called to order by President Hess at 9:45 A.M., with the following present:

Members: C. A. Adams, D. Arnott, F. W. Davis, J. H. Deppeler, O. B. J. Fraser, H. O. Hill, A. B. Kinzel, J. F. Lincoln, H. W. Pierce, H. M. Priest, R. D. Thomas and B. L. Wise.

By invitation: E. V. David.

Staff members: M. M. Kelly, W. Spraragen and L. M. Dalcher.

A.W.S. Organization

President Hess made reference to a report submitted by Mr. Lincoln at the Feb. 6, 1946, Board meeting and reminded the Board that this report was accepted and referred for study to the A.W.S. Special Committee on Organization, and to the Board of Directors with the minutes of the February 6th Board meeting. Prof. Hess stated that the Lincoln report had been studied carefully and discussed in detail by the Organization Committee. It was the opinion of the Organization Committee that it is better to make evolutionary changes, rather than revolutionary changes, when working toward improvement in the organization of A.W.S.

It was stated that the recommendations of the Organization Committee had been agreed upon unanimously, with the exception of Mr. Lincoln, who cast a negative vote.

After deliberation, report of the Committee on A.W.S. Organization to the Board of Directors was approved.

It was reported that Mr. Klinke assumed his duties as *Welding Handbook* Editor and Associate Secretary officially on June 1st, and during the intervening two months, he put some time on the work.

On motion, it was voted that the Board of Directors review progress one year hence.

Further, it was voted that the Committee on A.W.S. Organization be discharged with appreciation for its service.

A.W.S. Sections' Request for Additional Support

Considerable discussion ensued on the danger of acceding to request of Sections for additional support without knowledge of the Sections' programs and needs. In view of recent action in respect to the appointment of an Associate Secretary, with primary function to contact and service the Sections, it was deemed advisable to postpone action on proposals for further support of Sections until the Associate Secretary has had opportunity to make a survey and render report on the Sections' needs for carrying on worthwhile programs.

It was believed that possibly he may find there is need for raising the minimum requirement of members for a Section from 25 to 40 or 50, so as to enable the Section to operate satisfactorily; in some parts of the country, it may be found that additional financial support is needed to meet travel expense of desired speakers; in other parts it may be found desirable to combine Sections in certain localities, so as to insure soundness of one Section; in other cases, it may be found that assistance is needed in the selection of officers that will insure progress and continuity of the Section.

After deliberation, it was voted to table proposals on request for additional financial support to A.W.S. Sections.

It was further voted to authorize the setting aside of $1000 which, upon recommendation of the Associate Secretary and with the approval of the Finance and Executive Committees, can be allocated to the Sections for travel expense of speakers who do not have travel expense accounts.

Progress Report 1946 Annual Meeting

Mr. David, Chairman of the Convention Committee, reported that, A. H. Skean, Manager, Convention Bureau, Atlantic City, N. J., had notified Mr. Eisenman that it was not possible to arrange to hold the National Exposition the week of November 11th and that the only dates available were November 17 through 22, 1946. Letter ballots to the Directors of A.W.S. covering the proposed change of date, indicated their approval. Letter ballots sent to the members of the Convention Committee, Manufacturers Committee and Program Committee indicated approval of the members of these three committees also.

Mr. David further reported that a thorough inspection of the facilities of the Hotel Ambassador was made. This revealed that the hotel is well equipped to handle our Meeting. Three large public rooms are available for our Technical Sessions all week, so that a program including three simultaneous sessions at all times can be arranged, if desired. These three meeting rooms are of ample size to accommodate any crowd that we might expect. Also, there are a large number of excellent committee meeting rooms which will be available. The Renaissance Room, or main dining room, will be ideal for the Annual Dinner, while the Venetian Room will be very well suited to the President's Reception. The Hotel assured us of 500 sleeping rooms for A.W.S. members and guests. With few exceptions, all of these are twin-bedded rooms with bath. A considerable number of parlors and suites will be available to our members. It is believed that for the first time in a number of years there will be ample meeting rooms, committee rooms, sleeping rooms and other space to accommodate our members and guests. Furthermore, the Ritz-Carlton and Chelsea Hotels are next door to the Ambassador Hotel, and

Welding sections of Everdur well screen at Madison, Wis. Screen fabricated by Harrington & King Perforating Company, Chicago, Ill.; installed by McCarthy Well Company, St. Paul, Minn.; inset shows Mr. Howard Sechrest of Howard Machine & Welding Company, Madison, Wis.

TWENTY *Everdur* Sections welded end-to-end . . . form 270-ft. Well Screen

THE ACCOMPANYING PHOTOGRAPHS show installation of an Everdur* screen in one of the wells operated by the Water Department of the city of Madison, Wisconsin.

In this installation, twenty tubular sections, 12″ diameter, made of ⅛″ thick Everdur sheet were welded together with Everdur Welding Rod to form one continuous 270-ft. length. Held in position by a special jig, each section was tacked to the next one below, and the jig removed for completion of welding.

In addition to the above, Everdur Metal is widely used for sewage, chemical, petroleum and other types of equipment because its high strength, corrosion resistance and weldability permit durable, lightweight construction. 46197

*Reg. U. S. Pat. Off.

ANACONDA

Anaconda

WELDING RODS

THE AMERICAN BRASS COMPANY

General Offices: Waterbury 88, Connecticut

Subsidiary of Anaconda Copper Mining Company

In Canada: ANACONDA AMERICAN BRASS LTD., *New Toronto, Ont.*

no doubt will be able to take care of anyone who cannot be accommodated at the Ambassador Hotel.

An announcement of the Annual Meeting and hotel reservation cards have been sent out to the entire membership of A.W.S. by Miss Kelly. We understand that the Hotel Ambassador already has received requests for a number of room reservations for this occasion.

The National Technical Program Committee held their first meeting on March 15th and considered a large number of suggestions for papers, authors and presiding officers for the Technical Sessions, which have been received. Very good progress was made and a preliminary program already has been prepared and sent out to the members of the Program Committee. The Secretary was instructed to invite the authors to present the papers which had been approved by the Committee. A total of some twenty-one Technical Sessions, covering five full days, except Thursday and Friday afternoons, is contemplated.

On Monday, March 18th, Miss Kelly and Messrs. David, Spraragen and Vom Steeg, met with the Philadelphia Section Executive Committee at the Engineers' Club, Philadelphia, Pa., to discuss arrangements and plans for the 1946 Annual Meeting and to initiate the organization of local committees and activities. Mr. H. B. Seydel, Chairman-Elect of the Philadelphia Section, was appointed Vice-Chairman of the Convention Committee and Chairman in charge of Local Arrangements. He will select the personnel of all local committees and acquaint them with their duties.

A pool of the Philadelphia Section Executive Committee indicated that they favored the resumption of the President's Reception, Annual Dinner and Ladies' Entertainment. For the President's Reception, they favored cocktails served with potato chips and cocktail crackers. The cost of the President's Reception, as is customary, will be borne by the National Society.

New Jersey Section Annual Year Book

Consideration was given to communication, dated April 1st, from the Chairman of the New Jersey Section and to the by-law and ruling of the Board of Directors relating to solicitation of contributions by Sections. Discussion centered on whether solicitation of advertising for this book might be considered as interfering with the national advertising program. It was the sense of the meeting that inasmuch as a large percentage of the ads secured are local, the national advertising program will not be affected.

Upon motion, duly seconded, it was voted to approve the New Jersey Section's action in publishing a year book.

Recommendations of Technical Activities Committee

Upon motion, duly seconded, it was voted to approve recommendation of the Technical Activities Committee that Tentative Standards and Recommended Practices for Automotive Flash Butt Welding be adopted and published as a tentative standard of A.W.S.

Further, it was voted to approve recommendation of the Technical Activities Committee that revised Code for Arc and Gas Welding in Building Construction be adopted and published as a full standard of the SOCIETY;

Further, it was voted to approve recommendation of the Technical Activities Committee that the SOCIETY adopt the policy of classifying and titling codes, standards, specifications and other reports prepared by the technical committees, as either "standards" or "recommended practices," wherever possible, such change in policy to be reflected in titles of new and revised committee reports.

Recommendations of Publicity Committee

Upon motion, duly seconded, it was voted to approve recommendations of the Publicity Committee that J. S. Vreeland's resignation as Publicity Committee Secretary be accepted, effective April 15, 1946; that he be extended a vote of thanks for his accomplishments during his term as Secretary, that Charles L. Combes be appointed the Secretary of the Publicity Committee, effective April 16, 1946.

Engineering Foundation Grant to WRC

Upon motion, duly seconded, it was voted to endorse W.R.C.'s request of

"WILL I HAVE ENOUGH ACETYLENE FOR TOMORROW'S JOBS?"

You will—if you have a Sight Feed Generator

● You won't run out of acetylene if you have a Sight Feed Acetylene Generator. A glance at the hopper will tell you instantly how much acetylene you have available.

As a user of acetylene you know it is wasteful of both time and money to change cylinders or recharge a generator in the middle of a welding or cutting operation. Sight Feed's hopper eliminates this loss. Look at the hopper, it is Pyrex, you look through it, not into it. The carbide is always visible.

A Sight Feed saves 50% to 75% on acetylene costs.

Stop at your jobber's store and have him demonstrate the Sight Feed or write for free 16-page catalogue No. 44-G.

ACETYLENE GENERATORS • FLOODLIGHTS • FLARELIGHTS

ACETYLENE Sight Feed GENERATORS

THE SIGHT FEED GENERATOR COMPANY

RICHMOND, INDIANA

A Little Care Is Worth a Lot of Cure

(a rule that applies to resistance welding, too)

The most comprehensive book ever published on resistance welding. Complete with charts, diagrams and photographs. Free to those using resistance welding, when requested on company letterhead

RESISTANCE WELDING MACHINES are sturdily built—they don't wear out quickly if properly used. But, like other mechanical equipment, they need proper attention: they won't operate smoothly if carelessly maintained.

Do your operators, for instance, keep tips and holders smooth and free of foreign deposits? Do they clean and tighten all electrical connections in the secondary circuit regularly? Dress electrodes at proper intervals? If these things aren't done, perhaps your operators don't *know*. And that's where Mallory engineers are ready to help—to give you and your operators the benefit of expert experience. Begin by writing today for a free copy of the Mallory Resistance Data Book. Meanwhile, observe these do's and don'ts:

DO'S

1. Lubricate the resistance welding machine, motor, gears and slides at periodic intervals.
2. Clean all air or oil filters regularly.
3. Keep leather cup washers in air cylinders soft and pliable with light motor oil.

DON'TS

1. Shun lubricants which are not recommended by the welder manufacturer.
2. Don't use air operated machines when the oil bowl in the air line is empty.
3. Never permit oil or grease to come in contact with the transformer winding, electrical wires, or connections.

In the United Kingdom, made and sold by MALLORY METALLURGICAL PRODUCTS LTD. (An Associate Company of Johnson, Matthey & Co. Limited) Hatton Garden, London, E. C. 1

P. R. MALLORY & CO. Inc.

MALLORY STANDARD RESISTANCE WELDING ELECTRODES

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

Engineering Foundation for aid in the amount of $3000 in support of the research program.

Annual Publication of A.W.S. Year Book

It was voted that the annual publication of the Year Book be continued.

EXECUTIVE STAFF OF AMERICAN WELDING SOCIETY

Secretary, M. M. KELLY. Duties: Chief Executive Officer of the SOCIETY, in charge of Finances, Records, General Correspondence and Personnel, Secretary Convention Committee, Board of Directors and Standing Committees.

Associate Secretary and Editor Educational Books, H. O. KLINKE. Duties: Editor of A.W.S. *Handbook* and other Educational Books of A.W.S. In charge of local Section affairs.

Technical Secretary, L. M. DALCHER. Duties: In Charge of All Technical Committee Activities, Standardization and Technical Information Service.

Assistant Technical Secretary, S. A. GREENBERG. Duties: Assistant to Technical Secretary on Technical Committee Activities, Standardization and Technical Information Service.

Editor, THE WELDING JOURNAL, *and Director, Welding Research Council*, W. SPRARAGEN. Duties: Business Manager and Editor, THE WELDING JOURNAL; Secretary, National Program Committee, and In Charge of Research Work of the SOCIETY.

KLINKE JOINS SOCIETY

At the Board of Directors' meeting of the AMERICAN WELDING SOCIETY held on April 5th, Mr. Henry O. Klinke, Research Engineer of the Air Reduction Sales Co., was selected to become the new Editor of the AMERICAN WELDING SOCIETY *Handbook* and other educational books. Two editions of the *Handbook* have been published, the third will probably appear in 1948. Mr. Klinke brings to the SOCIETY in his capacity of Editor of the Educational Books a wide and varied experience in the welding field covering all the major processes and the applications of welding in several major industries.

In addition to his title of Editor of Educational Books, Mr. Klinke has also been given the title of Associate Secretary of the AMERICAN WELDING SOCIETY. A portion of his time under this new title will be devoted to Section affairs. Mr. Klinke expects to visit and service different Sections of the SOCIETY as may be necessary. He will serve as liaison representative of headquarters and the local Sections. In cooperation with the District Vice-Presidents he will be instrumental in stimulating the activities of the Sections.

Henry O. Klinke

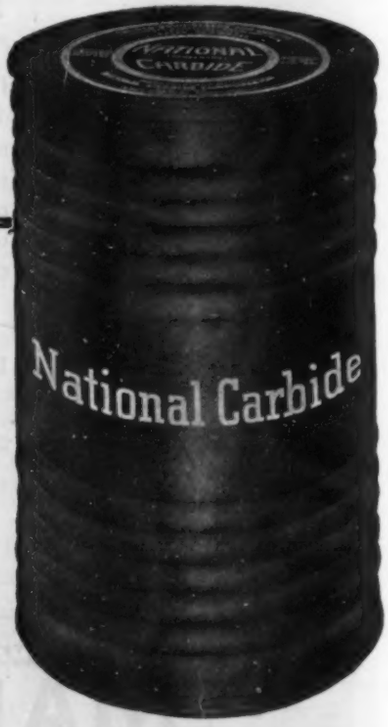
Mr. Klinke has demonstrated his ability for leadership in the way in which he has handled the affairs and meetings of the

National
Carbide
IN THE RED DRUM

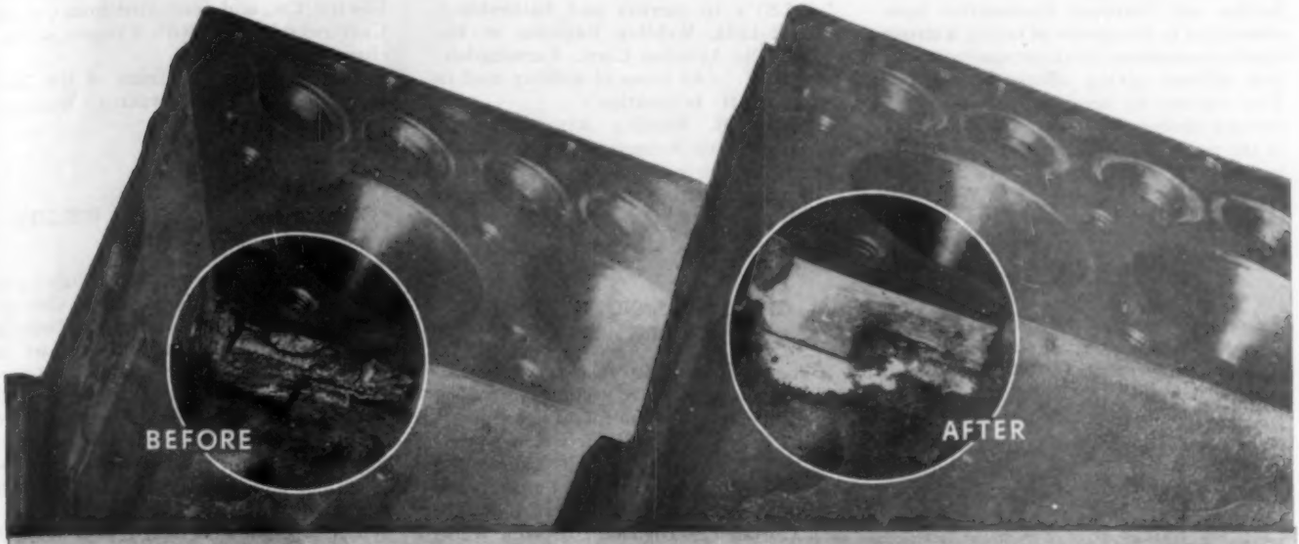
EFFICIENT

ECONOMICAL

DEPENDABLE



FOR WELDING and CUTTING
Use National Carbide in the Red Drum
Write us for information as to nearest available stock.
60 E. 42nd St. NATIONAL CARBIDE CORPORATION New York 17, N. Y.



NI-ROD REPAIRS CASTINGS Quickly Easily

With smooth-handling Ni-Rod available, you can effectively salvage castings with sound, *crack-free* welds.

These "BEFORE" and "AFTER" pictures show how welding with Ni-Rod cuts costs for a leading automobile manufacturer.

Left photo shows a defective cylinder block. Machining revealed a blowhole right at an important lug section.

Right photo shows the same block after the section had been ground down . . . built up with Ni-Rod . . . finished by grinding.

It is just as sound as a perfect casting.

No preheat was required and finishing was easy. The foundry reported Ni-Rod to be the best welding rod they ever used to repair castings.

You'll find plenty of jobs for Ni-Rod. Deposits are smooth, sound, strong, machinable, and close to the color of cast iron. Ni-Rod is easy to handle; slight variations in manipulation do not affect weld quality. And, you can use Ni-Rod on a.c. or d.c.

Order a 5-lb. package, and see for yourself how easy it is to salvage castings. Instruction booklet will be sent upon request.

INCO NI-ROD

THE INTERNATIONAL NICKEL COMPANY, INC. • 67 Wall Street, New York 5, N.Y.

DISTRIBUTED BY:

WHITEHEAD METAL PRODUCTS COMPANY, INC. — Baltimore-Boston-Buffalo-Newark-New York-Philadelphia-Syracuse

WILLIAMS and COMPANY, INC. Cincinnati-Cleveland-Columbus-Pittsburgh

PACIFIC METALS COMPANY, LTD. Los Angeles-San Francisco

STEEL SALES CORPORATION Chicago-Detroit-Milwaukee-Minneapolis-St. Louis

J. M. TULL METAL & SUPPLY CO. Atlanta

METAL GOODS CORPORATION Dallas-Houston-New Orleans-Tulsa

EAGLE METALS COMPANY Portland-Seattle

HENDRIE & BOLTHOFF MFG. & SUPPLY CO. — Denver

ROBERT W. BARTRAM — Montreal

ALLOY METAL SALES, LTD. — Toronto

WILKINSON COMPANY, LTD. Vancouver

Call or write for more information.

New York Section. His activities on Section and National Committees have shown him to be capable of taking a strong stand on questions, with persuasive power and without giving offense to anyone. This ability to meet with men on a friendly basis and to guide their thinking in the ways of sound judgment should be an excellent asset for his work in tying together the bond between A.W.S. Sections and Headquarters.

Brief Biography

Born—Fitchburg, Mass., June 9, 1908.

Education—Pittsfield High School, Pittsfield, Mass., 1928. Rensselaer Polytechnic Institute, E.E. 1932. Graduate work at Columbia University, 1942– .

Honorary Societies—Sigma Xi (1932). Professional Engineer N. Y. State #19105 (1938).

Technical Societies—AMERICAN WELDING SOCIETY, American Society for Metals.

Experience—

1932–1935, traveled in Europe.

1935–1937, Welding Engineer at RCA Manufacturing Co., Harrison, N. J. (Resistance welding of all-metal radio tube.)

1937–1938, Welding Engineer at Western Electric Co., Baltimore, Md. (Flash welding of Copper rod for wire drawing—spot welding of alloy steels for coaxial cable.)

1938–1942, Welding Engineer at U. S. Navy Yard, Philadelphia, Pa. (All types of welding, cutting and brazing incidental to fabrication of ships from LST's to carriers and battleships).

1942–1944, Welding Engineer at Republic Aviation Corp., Farmingdale, N. Y. (All types of welding used in aircraft fabrication.)

1944–1946, Welding Research Engineer at Air Reduction Co., New York. (Research in many phases of welding, oxygen cutting and scarfing, pressure welding, etc.)

CHAMPION ANNOUNCES NEW APPOINTMENTS

The Champion Rivet Co., Cleveland, Ohio, manufacturers of welding electrodes, has recently made the following appointments for the sale of their welding products: F. J. Sweeney (Cleveland and Akron District); Terminal Engineering & Supply Co., 47 Terminal Way, Pittsburgh, Pa. (Pittsburgh District); Norton Welding Equipment Co., 444 N. 29th St., Milwaukee, Wis. (State of Wisconsin).

R. M. WILSON JOINS INTERNATIONAL NICKEL

R. M. Wilson, Jr., has joined the Technical Service Section of the Development and Research Div. of the International Nickel Co., Inc., at New York, as a Welding Engineer.

He was formerly Welding Engineer at the Bloomfield, N. J. Works of the General Electric Co., and graduated from Cornell University in 1932 with a degree of Mechanical Engineer.

Mr. Wilson is Chairman of the New Jersey Section of the AMERICAN WELDING SOCIETY.

COMPARISON CHART OF WELDING MATERIALS

American Manganese Steel Division of American Brake Shoe Co., Chicago Heights, Ill., has just published Bulletin CC-2, styled "A Comparison Chart of Nickel-Manganese Steel and Hard-Surfacing Welding Rods and Electrodes."

The chart lists the fourteen Amsco welding rods and their applications, showing which Amsco rod to use for each application, and also identifies comparable rods of other makes.

The applications listed are: strength welds; build-up welds; abrasion with severe impact; severe abrasion with medium impact; severe abrasion with mild impact; dies, etc.; agricultural implement repairs; abrasion with medium impact; composite tools, dies, jigs, etc.; abrasion with shattering impact; red-hardness, abrasion, corrosion; tungsten carbide fines; and tungsten carbide particles.

This chart, which is definitely helpful in selecting the correct welding material for a specific application, will be mailed free upon request.

Are YOUR WELDING OPERATIONS LIKE A TRAFFIC LIGHT?

● You can eliminate costly "Stop-Go, Stop-Go" operations in your shop by installing the RegO Manifold designed for your requirements.

You not only gain the advantage of uninterrupted operations, but also save valuable production space and eliminate hazards.

Learn about *all* the advantages you can get with RegO Manifolds . . . there's no obligation . . . write today!

REGO ARMY E NAVY

The BASTIAN-BLESSING Company

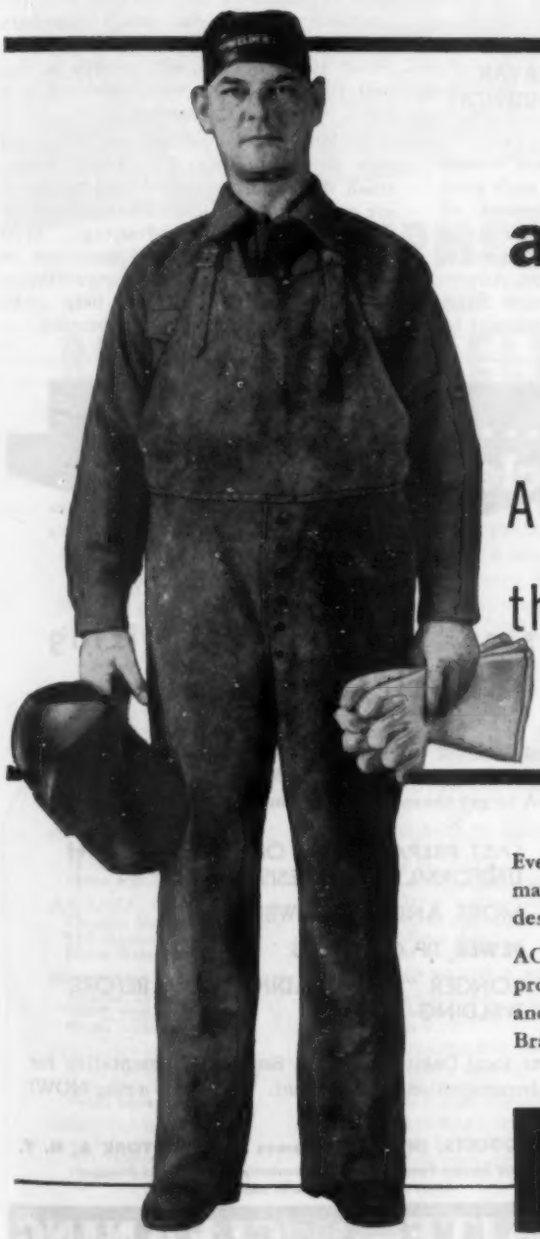
4241 Peterson Ave. • Chicago 30, Ill.

Pioneers and Leaders in Equipment for Using and Controlling High Pressure Gases

A-O

Safety Goggles Safeguard the Eyes of Industry • Reduce Production Costs

and



AO Safety Clothing Protects the Worker from Head to Foot

Every item in the complete AO Safety Line has been planned to provide maximum protection with the greatest possible comfort. This careful designing contributes materially to faster production and lower costs.

AO's Safety Line includes safety goggles of every type; respirators for protection against more than 140 hazards to lungs and respiratory systems; and wide variety of safety clothing and equipment. Your nearest AO Branch Office will be glad to send you complete details.

American Optical COMPANY *Safety Division*

SOUTHBRIDGE, MASSACHUSETTS
BRANCHES IN PRINCIPAL CITIES

AMERICAN ARC WELDING PATENTS

American Arc Welding Patents, edited by W. H. Simon, Ph.D. Volume I. Materials, Accessories. Electrodes, Welding Rods, Alloys, Electrode Holders, Welding Shields. 574 pages, 426 illustrations, Demy Quarto, bound in maroon rexine. Publisher, McAirish & Co. Limited, 388 Yorke St., Toronto, Canada.

The subject matter of this work is electric arc welding. However, many gas welding material patents, especially on welding rods, alloys and also various gas welding applications apply to both processes; the latter are therefore included in this volume except those on equipment.

As this book gives the date on which each patent expired or will normally expire, it will not only help to avoid infringement, but will also enable engineers and researchers to utilize inventions which, on expiration, have become public property. It will also be a guide to users of welding equipment and materials, since it lists the names of those inventors concerned with the solution of special welding problems. Reference to its pages will further help them in assessing the value of patents mentioned in advertising literature.

The first volume gives the patent position existing on July 1, 1945, classified up to April 1, 1945. It lists the few basic patents of the time when arc welding was in its infancy. It covers a period of 63 years and contains 1250 patents, the majority of which refer to the time when welding was established as a standard engineering process.

Dr. Wendell F. Hess states: "In my opinion, Dr. Simon's patent survey will serve as an excellent guide to the patent literature in the field of welding. The classification of patents has been handled in an excellent manner, to provide a ready reference to patents in different fields. The ability to refer easily to the patent literature in one's field is of particular advantage to development engineers, designers and research workers. The ability to determine quickly and easily the important provisions of various patents should tend to avoid much useless litigation."

CHAMPION TRANSPORTATION SALES, INC

The Champion Transportation Sales, Inc., has been formed to handle the sales of railway supplies on a national basis. Their office will be located at 9 South Clinton St., Chicago, 6, Ill.

THE VALLEY FORGE CARAVAN SALUTES THE WELDING EQUIPMENT INDUSTRY!

Our hats are off to the men and women who manufactured and used to such good advantage the welding equipment of America. We honor tonight such hosts as Mr. B. J. Tesmer, Treasurer of Burdett Oxygen Co., Mr. G. Van Allstyne, Advertising Manager of Air Reduction Sales Co., and Mr. W. W. Reddie, Assistant to the Manager of the Welding Department of the Westinghouse Electric Corp.

The process of welding dates back to about 1880 when two discoveries were made almost simultaneously: one which produced flame welding by the oxyacetylene torch and the other, arc welding by use of the electric arc. It was found that the extremely high temperatures of the flame and arc methods would weld metals and result in a strength equal to or greater than that possessed by the metal itself. World War I gave needed impetus to the welding industry, for then its many advantages became apparent during salvage work on sabotaged enemy ships. Flame cutting by the oxygen stream and welding by the oxyacetylene and electric arc methods became established completely when in World War II this became the primary process of metal fabrication. Welding brought heretofore unknown economies. Welding, brazing, flame hardening, cutting and hard-facing of metals gave nine lives to industry's hard working tools and machinery when war made necessary around the clock shifts in every industry. From 1939 to 1945, the growth in this still young industry was registered in a 625% increase in the market.

No longer is the welding machine a tool only for big industry . . . today, home, small shop and farm-type welding outfits are available and America has trained the men to use them to advantage. It is soundly judged that the operation of welding by electric arc or oxyacetylene flame is here to stay and help make America grow for benefit to all peoples.

INCREASES EFFICIENCY 20%

GARIBAY '350'

350 AMPERES CONTINUOUS CONDUCTIVITY

ELECTRODE HOLDER
PATENTED

Light weight, fully insulated
Full view of work
Natural welding position
Scientifically ventilated
Ideal mechanical cable connection

Distributors Wanted
Write in for Territories

GARIBAY MANUFACTURING CO.
1517 COLEGROVE AVE., MONTEBELLO, CALIF.

"Welding Tools Designed for Efficiency"

. . . is THIS your cleaning problem?

Faster, Better Deoxidizing of Alclad Surfaces

For spot welding pre-treatment on Alclad stock, use the effective oxide-removing properties of Oakite Compound No. 84-A to get these four important advantages:

- √ FAST PREPARATION OF SURFACES WITH UNIFORMLY LOW RESISTANCE
- √ MORE AND BETTER WELDS
- √ FEWER TIP CHANGES
- √ LONGER "SAFE-HOLDING" TIME BEFORE WELDING

Ask your local Oakite Technical Service Representative for FREE demonstration in your plant. Give him a ring NOW!

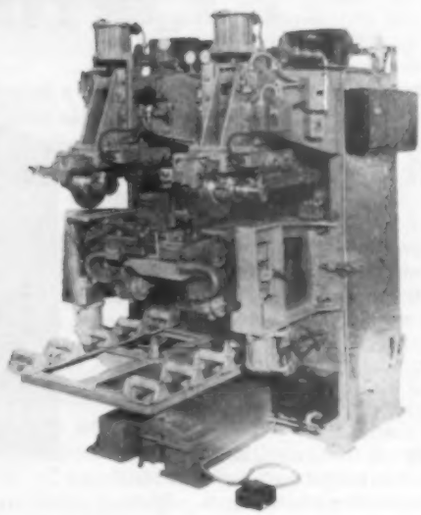
OAKITE PRODUCTS, INC., 18E Thames St., NEW YORK 6, N. Y.
Technical Service Representatives Conveniently Located in All Principal Cities of the United States and Canada

OAKITE *Specialized* CLEANING
MATERIALS · METHODS · SERVICE · FOR EVERY CLEANING REQUIREMENT

NATIONAL has the ENGINEERING EXPERIENCE

and the EQUIPMENT to solve your RESISTANCE WELDING PROBLEMS

No, sir—NATIONAL Welders are not designed by "guess artists." These men know welding—they've grown up on it—have dreamed about it—eaten it—played with it—and worked at it—twenty-four hours a day for many, many years. Naturally, they know more about welding—and that's why they are "tops" today in the welding field. Think of it—an organization that has grown by leaps and bounds until today the first thought of smart production men on welding is NATIONAL.



NATIONAL

MANUAL · AIR · HYDRAULIC · MOTOR DRIVEN · SPOT · PROJECTION · SEAM · BUTT · FLASH & SPECIAL WELDERS

ALBANY 7, NEW YORK
R. L. Browne
75 State Bank Bldg.
Phone 4-2175

ATLANTA, GEORGIA
Chandler Machinery Company
120 Houston St., N.E.
Phone Walnut 3343

BIRMINGHAM, ALABAMA
National Cylinder Gas Co.
709 S. 21st Street
Phone 7-7697

CHICAGO 12, ILLINOIS
J. M. Cooper
9 So. Kedzie Ave.
Phone Sacramento 1506

CINCINNATI 2, OHIO
L. J. Gottschalk, Jr.
831 Temple Bar Bldg.
Phone Parkway 2030

CLEVELAND 18, OHIO
W. O. Little
3109 Mayfield Road
Phone Yellowstone 6360

DETROIT 2, MICHIGAN
Arthur B. Sonneborn Co.
631 Fisher Bldg.
Phone Trinity 2-2760

GRAND RAPIDS 4, MICHIGAN
Joseph Monahan
351 Indiana Ave., N.W.
Phone 8-5917

INDIANAPOLIS 4, INDIANA
Engineering Sales Co.
621 N. Illinois St.
Phone Franklin 2381

LOS ANGELES 15, CALIFORNIA
George S. Tivy
1148 S. Grand Ave.
Phones Prospect 8806 and 1686

MEMPHIS, TENNESSEE
National Cylinder Gas Co.
504 McCall Bldg.
Phone 8-4228

MINNEAPOLIS 2, MINNESOTA
Chas. W. Stone
1019 Marquette Ave.
Phone Geneva 8631

NEW ORLEANS 13, LOUISIANA
Patrick H. Dillon
524 Howard Ave.
Phone Raymond 1214

PHILADELPHIA 30, PENNSYLVANIA
K. Wm. Ostrom & Co.
1622 Fairmount Ave
Phone Stevenson 4672

ST. LOUIS 8, MISSOURI
Clements Welding Supply Co.
709 Academy Avenue
Phone Forest, 4950

SEATTLE, WASHINGTON
Northwest Equipment Co.
1140 W. 53rd St.
Phone HE 3300

WASHINGTON 5, D. C.
Paul Werres
1507 M Street, N.W.
Phone National 5812

MEMBER RESISTANCE WELDER MANUFACTURERS ASSOCIATION RWMA

NATIONAL ELECTRIC WELDING MACHINES CO. 1850 N. TRUMBULL ST., BAY CITY, MICHIGAN, U. S. A.

Manufactured in CANADA by ENGLISH ELECTRIC COMPANY of Canada, Ltd., St. Catherines, Ontario
District Offices: Montreal, Toronto, Ottawa, Kirkland Lake, Vancouver. Representation in Halifax, Winnepeg, and Edmonton.
Distributed in Canada by Rudel Machinery Company, Offices in Montreal, Toronto, Windsor, Vancouver

We honor you men and women of the Welding Equipment Industry tonight . . . for much of the credit for the strength that America showed during wartime and will now show in peace was due to your efforts in advancing the Industry that we salute tonight with this 1160th broadcast of the Valley Forge Caravan!

SUPPLEMENT TO BOOK OF A.S.T.M. STANDARDS

To keep up to date the biennially published Book of A.S.T.M. Standards, the American Society for Testing Materials in the intervening year issues Supplements to each part of the book. The 1945 Supplements recently issued in three parts, give in their latest approved form some 230 specifications, tests and definitions which were either issued for the first time in 1945 or revised since their appearance in the 1944 Book.

Part I on Metals, some 395 pages, includes over 85 standards covering ferrous and nonferrous materials. The section on ferrous metals includes steel, wrought iron, pig iron, etc. (9); electrodeposited coatings (8); also three general testing methods. Nonferrous specifications and tests include copper and copper alloy products—tubes, strip, etc. (32); copper and copper alloy castings (8); lead and lead alloys (2); anodic coatings (3); copper wire (8); electric furnace alloys; magnesium and its alloys (7); materials for radio tubes, electronic devices and lamps (7); and metal powder bearings.

Part II on Nonmetallic Materials (Constructional), 250 pages, has 50 standards. Subjects covered include lime, filter block, glass, soils (5); refractories, fire brick (14); thermal insulating materials (11); roofing materials, wood (3); paint, varnish, lacquer, etc. (16); naval stores (4); and thermometers.

Part III on Nonmetallic Materials (General), the largest volume, with 500 pages includes over 95 standards. Specifications and tests cover coal, thermometers (2); petroleum products and lubricants (10); electrical insulating materials (12); plastics (15); rubber products (4); shipping containers (2); textile materials (11); paper and paper products (12); soaps and other detergents (6); naval stores (4); water for industrial uses (4); and industrial aromatic hydrocarbon (19). Copies of these supplements can be obtained from A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa, at $4 per Part, all three Parts, $12. Each is bound in a durable cloth binding with a back strap designed to match the 1944 Book of Standards. Heavy leather bindings are available upon the additional payment of $2 per Part. The three 1945 Supplements, plus the Book of Standards, give a complete set of all A.S.T.M. specifications and tests, excepting those on chemical analysis of metals which are in a special volume.

HEATING AND VENTILATING SOCIETY

The American Society of Heating and Ventilating Engineers, 51 Madison Ave., New York 10, N. Y., has purchased property at 7218 Euclid Ave., Cleveland 3, Ohio, to provide adequate research facilities for serving the entire heating, ventilating and air conditioning industry as well as the associated industries, according to the announcement of Alfred J. Offner, President. The move to the new home for the Society's Research Laboratory was effective April 1st. According to Mr. Offner, this represents another forward step in the Society's Research Program, which is in its 27th year and which is unique among national engineering societies.

The property consists of a substantial dwelling with a large two-story brick auditorium type building attached. Its location on one of Cleveland's main traffic arteries makes the Laboratory accessible from the center of the city and from the east side railroad stations.

The brick building, which is 58 x 125 ft. on its foundation houses the Laboratory proper. At grade level are three large rooms with 11-ft. ceilings and numerous small service rooms totaling about 5300 sq. ft. which provide excellent research, workshop and storage facilities. The only basement space is that provided for the heating plant.

BUILDING CODES

A revised edition of the AISC Specification for the Design, Fabrication and Erection of structural Steel for Building, was adopted by the Board of Directors of the Institute on February 14th of this year.

This 1946 edition constitutes the first extensive revision of the Institute's standard specification since it was first published under the present title in 1936, at which time the allowable stresses were raised to the so-called 20,000 lb. basic stress to reflect a correspondingly higher minimum yield point specified for structural steel under A.S.T.M. A-9 and A-7 (combined in 1939 as a single standard, A-7).

Much of the present revision was necessitated by the inclusion of material previously published by the Institute as a separate tentative standard specification for the Design, Fabrication and Erection of Structural Steel for Buildings by Arc and Gas Welding (January 1942).

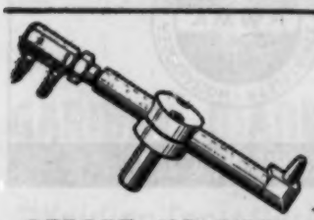
Other significant changes are as follows:

1. The allowable unit stress for tension on the section through the throat of butt welds, on the nominal area of rivets and on the area at the root of the thread of bolts, has been raised to 20,000 psi. The action with respect to butt welds is in agreement with a similar recommendation which will be contained in the 1946 Edition of the A.W.S. Building Code to be issued later this year. It appears to be fully warranted by the accumulation of test data indicating a tensile strength in butt welds fully equal to that of the base metal.

2. Recognition of the theory of limit design, as a proper approach to the design of continuous beams, girders and rigid frames, is reflected in new provisions under Section 15 (a) 3 which permit an increase not in excess of 20% in the allowable unit bending stress, when such stress is maximum at supports and is induced by gravity loading.

ELECTRODE CORRELATION CHART

A large-sized data sheet, folding into an $8^1/_4$- x 11-in. cover, lists every well-known stainless steel by trade name with the proper Arcos alloy electrode for welding each. AISI type numbers and analyses of the trade-named stainless steels are given, as well as the weld metal chemical analysis of the corresponding Arcos electrodes. A copy of this correlation chart will be sent to you on request. Arcos Corp., 310 Gulf Bldg., Philadelphia 2, Pa.



Industry Endorses EUTECTIC *Low Temperature* WELDING RODS* and FLUXES

World's Largest Helicopter —welded with EUTECTIC

Aircraft construction must be dependable in order to assure the utmost safety for both men and machines. The world's largest helicopter, the PV-3 Transport Helicopter, was built according to sound engineering principles of construction that required the use of *high quality and dependable* welding materials.

Built by the Piasecki Helicopter Corporation, Sharon Hill, Pa., for Navy and Coast Guard rescue and transport service, this helicopter is capable of carrying twelve persons. The welding designs called for the use of EUTECTIC *Low Temperature* WELDING RODS* for the joining of steel, cast iron, aluminum, other non-ferrous alloys, and for hard surfacing. These revolutionary welding rods were used because they did a better welding job—making possible lighter, stronger, more durable parts, and greater economy in manufacture.

EUTECTIC *Low Temperature* WELDING RODS* are an effective advancement towards welding perfection. With most of these alloys, a welded unit of flawless construction and high physical properties can be obtained at *welding temperatures far below the melting points of the base metals*. Thus, the inevitable results of high welding heats—shrinkage, distortion, and residual stresses can be greatly minimized. Tough welding problems can be solved easily. In most cases, only a thin film of alloy is necessary to make a strong, durable joint *without affecting the inherent properties of the base metal*. Practically any part that requires welding can be improved by the use of EUTECTIC *Low Temperature* WELDING RODS.*

This remarkable development in welding is not only adaptable to aircraft construction, but also to all types of production welding where stresses and distortion caused by high heat cannot be tolerated. In addition, EUTECTIC *Low Temperature* WELDING RODS* play an indispensible role in the welding maintenance and repair field. They can be used with any source of heat—oxyacetylene torch, metal arc, furnace and induction heating, etc. EUTECTIC conducts one of the largest research programs in the welding and brazing field. Our Engineering and Service departments will gladly consult with you and help solve your welding problems.

The best way for you to learn and profit from the unusual advantages of EUTECTIC *Low Temperature* WELDING RODS* and Fluxes is to use an assortment of the 9 most useful EutecRods for your everyday use. We will send you full information or have one of our Field Engineers call to discuss your welding problems. For your convenience use the coupon below.

For Your Welding Problems—Call* EUTECTIC *First

140 Field Engineers, in all principal cities of the United States and Canada, to serve you.

*Trade-mark Reg. U. S. Pat. Off.

EUTECTIC WELDING ALLOYS CORPORATION
ORIGINATOR OF *Low Temperature* WELDING ALLOYS
40 Worth Street **New York 13, N. Y.**

☐ Please send information on assortment of 9 EutecRods.

☐ Please have your Field Engineer call to see us. Dept. WJ-6

NAME.....

COMPANY.....

ADDRESS.....

A.S.T.M. ANNUAL MEETING IN BUFFALO, JUNE 24–28

In addition to the 23 formal technical sessions which are part of the technical program for the Forty-Ninth (1946) Annual Meeting of the American Society for Testing Materials in Buffalo, June 24 to 28, inclusive, there will be more than 200 meetings of the Society's technical committees. The Seventh Exhibit of Testing Apparatus and Related Equipment will be in progress, and the Annual Photographic Exhibit also will be held. All sessions will be at the Hotel Statler.

More than 150 technical papers and reports by the country's leading authorities in the field of materials are scheduled, many of them to comprise parts of symposiums.

A.S.T.M. NEW HEADQUARTERS

The American Society for Testing Materials which for a number of years has had its headquarters at 260 S. Broad St., Philadelphia 2, Pa., now occupies its permanent headquarters building at 1916 Race St., Philadelphia 3, Pa. This building, which was purchased and remodeled through contributions made by many of the companies and individuals active in the Society's work, will provide much needed additional space that is required by the expansion of the Society's staff. The technical work in which A.S.T.M. since 1898 has concentrated its activities, namely, the development of standard specifications and tests for materials and the promotion of knowledge of properties of materials through research, has necessitated a considerable expansion of the headquarters group.

For a number of years many of the A.S.T.M. leaders have hoped that there would be an opportunity to obtain a permanent headquarters building, and this now has been achieved.

The new building is strategically located on Philadelphia's Parkway, adjacent to the Academy of Natural Sciences and close to the Franklin Institute and the main Philadelphia Free Library.

The new telephone number is RITtenhouse 5315.

LINCOLN'S INCENTIVE SYSTEM

Book by James F. Lincoln, President, The Lincoln Electric Co., Cleveland, Ohio, describes the successful management plan of this Company. Here are the fundamentals and methods of application of the incentive plan of management, and the history of its use in The Lincoln Electric Co., where it has resulted in an increase of output per man per year of more than twelve times. The plan, presented for the first time as a result of actual, successful application to industry, may be applied universally in all activities which require cooperative action by a number of people. This presentation demonstrates to management the extreme practicality of the cooperative system, and illustrates step by step the details of its practical use. Published by the McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 18, N. Y., $2.00.

BUILD YOUR OWN GAS DRIVE WELDER

The Hobart Brothers Co. offers a new, 48-page book titled "How to Build Your Own Gas Drive Welder." This book takes the reader through a progressive step-by-step plan, showing actual photographs, plans and ideas for the home builder. Ask for EW-113, available at no charge from the Hobart Brothers Co., Troy 1, Ohio.

OGILVIE MADE DISTRICT MANAGER

The Gasflux Co., Mansfield, Ohio, announces the appointment of Douglas C. Ogilvie as Eastern Division Manager, with headquarters at 487 Orange St., Newark 7, N. J. Mr. Ogilvie was formerly connected with the Chas W. Krieg Co., of Newark, in the capacity of Welding Consultant. In his new position he will provide field service for the accounts of distributors in New England, Eastern New York, Eastern Pennsylvania, New Jersey, Delaware and Maryland. Chas. W. Krieg Co. will continue to handle the distributorship of Gasflux Units and Gasflux in New Jersey and New England.

PHOTOELASTIC STRESS ANALYSIS PAMPHLET

To provide engineers and scientific investigators with a compact but comprehensive survey of the general photographic aspects of photoelastic stress analysis, the Eastman Kodak Co. is now offering free of charge an 8-page folder which gives background information and basic working specifications for this technique.

Titled "Photoelastic Stress Analysis," the pamphlet briefly covers such subjects as the optical theory, apparatus, the model, photographic materials, analysis of the records obtained and three-dimensional analysis.

A copy of this pamphlet may be obtained free by writing the Sales Service Div., Eastman Kodak Co., Rochester 4, N. Y.

HYDROGEN AIDS WELDING

Operator spot welds the parts of an 857 rectifier tube at the Brooklyn plant of Amperex Electronic Corp.

Small rubber tube shoots a jet of hydrogen on the work to prevent formation of oxides and occlusion of oxygen in the heated metal.

Very heavy tungsten leads are necessary in order to carry the 40-amp. filament current.

Buy "Proven Fluxes" with Years of Guaranteed Satisfaction behind them
The Trade-Name is "ANTI-BORAX"

Ask for Them ***Unequalled for Quality***

A Flux for every metal: Cast Iron Welding Flux No. 1; Brazing Flux No. 2; Braz-Cast Flux No. 4 for bronze-welding cast iron; "ABC" Aluminum Flux No. 8 for sheet Aluminum and all alloys of Aluminum; Stainless Steel Flux No. 9; Silver Solder Brazing Flux No. 10; No. 16 Silver Solder Paste Flux.

ANTI-BORAX COMPOUND COMPANY

Fort Wayne, Indiana

Time Counts—
Gas cut and Weld with

Shawinigan Carbide

SHAWINIGAN

SHAWINIGAN PRODUCTS CORPORATION
EMPIRE STATE BUILDING, NEW YORK 1, N.Y.

The GOGGLE welders asked for is HERE!

1. Goggle in regular welding position

2. Pull outward and upward with either hand

3. Goggle rests on forehead during layout or inspection of work

The New CESCO Aristocrat with *Speed-Shift* Suspension

HERE IT IS! The CESCO Aristocrat Welders Goggle—with patented coil-spring suspension. A quick flip moves the goggle onto the forehead or back into position. Saves time! Promotes efficiency!

That's not all—this goggle increases welders' comfort too. The spring action is mild enough to eliminate pressure. The cups rest comfortably, and are adjustable to individual facial requirements. The headgear is made of lightweight, flexible, form-fitting plastic, and is easily adjusted to any head size.

WRITE for literature and prices.
For quick delivery, get your order in soon.

This CESCO *Air-Flow* Helmet is proving its worth to welders

CESCO'S recent development—the *Air-Flow* Welding Helmet—is consistently proving to be a remarkable success. Its superior, exclusive method of air feeding disperses fumes and heat—reduces fatigue, increases production. It combines assured welding safety and "air-conditioned" comfort. For complete information write for BULLETIN B.

CHICAGO EYE SHIELD COMPANY
2332 Warren Boulevard • Chicago 12, Illinois

CESCO

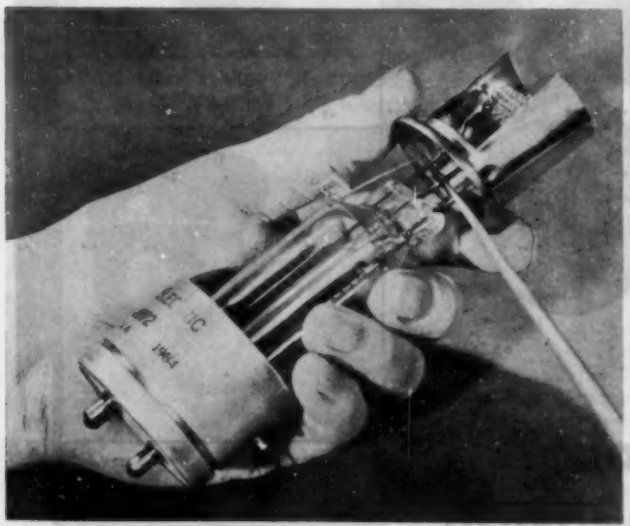
CESCO FOR SAFETY

NEW MOVIE, "THIS IS RESISTANCE WELDING"

A new 16-mm., all-color sound movie, "This Is Resistance Welding," designed to promote a still broader understanding of the operating principles and the many advantages of the more widely used types of resistance welding, has been announced by the General Electric Co. The new film, which requires about 30 minutes to exhibit, is available for loan without charge through electric utilities, welder manufacturers and G-E offices throughout the country for exhibition before engineering and manufacturing groups, schools and other groups interested in resistance welding. The movie is part of General Electric's well-known More Power to America program.

Produced by the Raphael G. Wolff Studios, Hollywood, under the technical supervision of the G-E welding laboratories, the film emphasizes throughout the important role resistance welding is playing in the high-speed, quantity production of innumerable products in a wide variety of sizes, shapes and materials. Products ranging in size from the massive steel shell of a railroad coach to an electronic tube filament only one-thousandth of an inch thick are shown being fabricated easily, quickly, efficiently and economically by resistance welding.

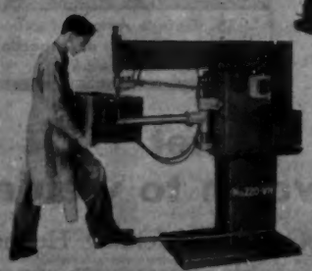
Following a colorful introduction in which a striking parallel is drawn between



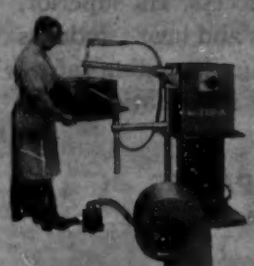
Close-up of a Tiny Electronic Tube Filament Fabricated by Resistance Welding

An Oxygen Tank, an Ignitron Tube, an Oil Diaphragm, and an Ammunition Container Fabricated by Resistance Welding

SPOT • BUTT • ARC
WELDERS



AIR, FOOT or MOTOR Operated Press Type Welders of All Sizes.



We manufacture a complete line of resistance spot welders from ¼ to 300 KVA for all types of welding. There is an EISLER WELDER for every purpose.

Transformers of all types.

We invite contract spot welding in large or small quantities.

Write for Catalog

EISLER ENGINEERING CO.

779 So. 13th St. (near Avon Ave.) Newark 3, N. J.

TIP CLEANING **DRILLS**
Mounted in Knurled
BRASS *Handled*

LARGE STOCK
PROMPT DELIVERY
NO RATING REQUIRED

DISTRIBUTORS WANTED
NEW MEXICO STEEL CO.
Box 691, Albuquerque, N. M.

Resistance Welding Equipment Manufacturer desires Sales Representative.

Excellent territory available for individual thoroughly familiar with spot welding application. We manufacture a complete line of equipment and are well established. Box No. V-191.

These RWMA bulletins serve your needs for information on resistance welding operations

Mechanical Characteristics of Resistance Welds in Plain Carbon Steels
BULLETIN NO. 11
BULLETIN NO. 13
Selected Papers on Spot Welding of Aluminum Alloys
BULLETIN NO. 12
RESISTANCE WELDING
Current Measurement

In order to keep you abreast of important developments in resistance welding that have been made possible by scientific research and by industry improvement, the Resistance Welder Manufacturers' Association makes available to you without charge the publications below.

Resistance Welding Equipment Standards (July, 1944)
Mechanical Characteristics of Resistance Welds in Plain Carbon Steels (A review of the literature to January 1, 1944)

BULLETINS

No. 1—The Elements of Resistance Welding
No. 2—Resistance Welding Current Measurement
No. 3—Standardized Ratings for Resistance Welding Contactors
No. 4—Pulsation Welding
No. 5—Resistance Flash Welding of Strip in Steel Mills
No. 6—Electro-Brazing Methods
No. 7—Electrical Characteristics of Resistance Welders
No. 8—Selected Papers on Spot Welding of Aluminum Alloys
No. 9—The Spot-Welding Properties of Rust-Proofed Mild Steel Sheet
No. 10—Flash Welding of Alloy Steels
No. 11—Application of Quality Control to Resistance Welding
No. 12—Flash-Butt Welded Joints—Their Design and Properties
No. 13—Resistance Welding Fundamentals

Additional bulletins will be issued from time to time. On request, your name will be added to the mailing list to receive future numbers.

RESISTANCE WELDER MANUFACTURER'S ASSOCIATION
505 Arch Street ● Philadelphia 6, Pa.

$2000 in PRIZES

for Papers on

RESISTANCE WELDING

Three cash prizes totaling $1500 will be awarded in 1946 for the best papers emanating from industrial sources and describing important accomplishments in resistance welding. Subject matter may be concerned with design, redesign, economics, procedure control, research, process development or other significant phases of the art.

Other cash prizes are offered for papers emanating from university sources. Write to Resistance Welder Manufacturers' Association for complete information.

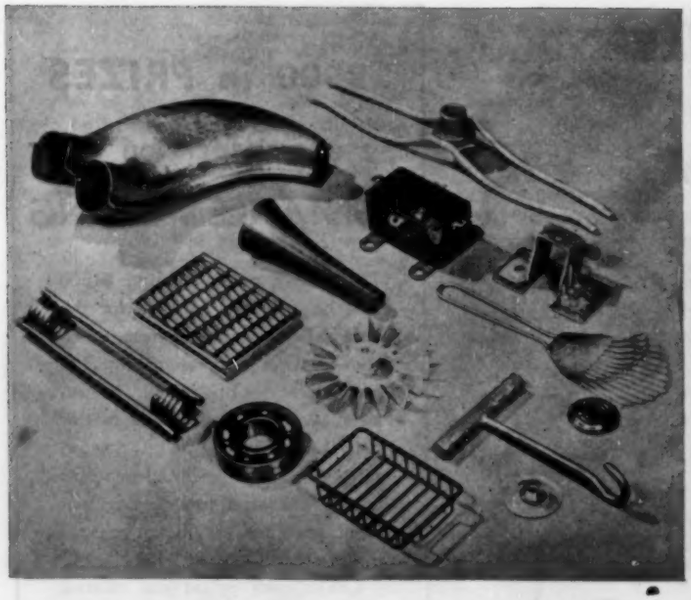
RESISTANCE WELDER MANUFACTURERS ASSOCIATION · RWMA

MEMBERS OF RWMA

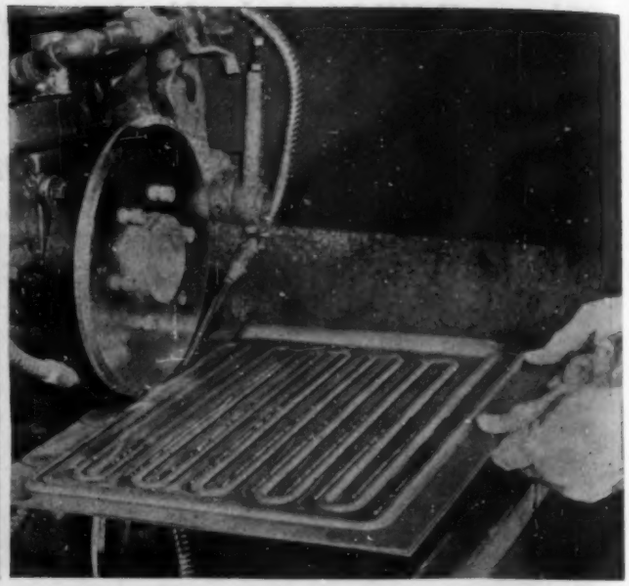
Acme Electric Welder Company
Los Angeles 11, California
Eisler Engineering Company
Newark, New Jersey
Expert Welding Machine Company
Detroit, Michigan
The Federal Machine & Welder Company
Warren, Ohio
Multi-Hydromatic Welding & Mfg. Co.
Detroit, Michigan
National Electric Welding Machines Co.
Bay City, Michigan
Progressive Welder Company
Detroit 12, Michigan
Resistance Welder Corporation
Detroit 2, Michigan
Rex Welder & Engineering Company
Kansas City 8, Missouri
Sciaky Brothers
Chicago 38, Illinois
Swift Electric Welder Company
Detroit 10, Michigan
Taylor-Hall Welding Corporation
Warren, Ohio
The Taylor-Winfield Corporation
Warren, Ohio
Thomson-Gibb Electric Welding Co.
Lynn, Massachusetts
Welding Machines Manufacturing Co.
Detroit, Michigan

THE ALLOY GROUP

Ampco Metal, Incorporated
Milwaukee 4, Wisconsin
Electroloy Company, Incorporated
Bridgeport, Connecticut
P. R. Mallory & Company, Incorporated
Indianapolis, Indiana
S-M-S Corporation
Detroit 11, Michigan
Weiger Weed & Company
Detroit 4, Michigan
Welding Sales & Engineering Company
Detroit, Michigan



Miscellaneous Small Parts Fabricated by Resistance Welding



Close-up of a Refrigerator Evaporator Being Fabricated by Seam Welding

modern resistance welding technique and the primitive heat-and-pressure method of the village blacksmith of old, the movie opens with a detailed explanation of the operating principles of resistance welding generally. Animated drawings and clear close-ups show how the pieces of metal to be welded are held, under continuous, correct pressure, between the electrodes of the welding machine while carefully timed, low-voltage, high-amperage, direct current or alternating current fuses them together.

Next are shown the four principal types of resistance welding—spot, seam, projection and flash welding. The operating principles, the distinct advantages, and the special capabilities of each of these important types are described in interesting detail. Spot welding, the type most extensively used, is shown as a technique by which fitted pieces of metal are joined together by fusing one spot at a time. Projection welding is depicted as a technique by which a projection on the surface of the work itself, rather than the shape of the electrodes, is used as a simple means of concentrating the welding current, thus localizing the heat and determining the size and shape of the weld. Seam welding is pictured as a method by which the current is applied at regular intervals by water-cooled electrodes, usually in wheel form, to make a series of automatically timed spot welds. Flash welding, which is a specialized form of welding and consequently differs from the other types, is shown as a process by which two pieces of metal are fused end to end.

Following this, the film reveals how quantity production is made possible by the efficiency of modern resistance-welding machines, with their accurate pressure control, low inertia of moving parts, versatility, high speed and low maintenance. The basic operation of synchronous electronic control equipment, which is used to bring new standards of precision in the regulation of welding current, is then described. The resistance of the work-material to the current, the magnitude and the timing of the current, all so important in the control of resistance-welding current, are explained in a series of interesting close-ups and animated diagrams.

The remainder of the movie is devoted to many typical examples of how electronically controlled resistance welding is cutting costs, increasing production, opening new fields of employment and progressing to new realizations of industrial achievement.

OBITUARY

George M. Deming

George M. Deming was born February 15, 1893, in San Bernardino, Calif. His college training at the University of Washington was interrupted by World War I when he entered the Army Chemical Warfare Service. Following the war, he served at the Bureau of Standards for two years. During this period he became interested in the oxyacetylene industry, since a major portion of his work at the Bureau consisted of gas welding and cutting problems. Mr. Deming then returned to the University of Washington, receiving the degree of B.S. in Chemical Engineering in 1922. After graduation, he was associated with the Pacific Telephone Company in Seattle for two years. He spent the year 1924 in the U. S. Patent Office in Washington, D. C., serving as a Patent Examiner.

Mr. Deming actively entered the welding industry when he joined the Air Reduction Sales Co. in February 1925 as an Associate Engineer in the Apparatus Research and Development Department. During the succeeding years he contributed greatly to the growth of the entire oxyacetylene industry by his outstanding research and development on equipment and processes, notably in the gas control and oxygen cutting fields. He had several patents and technical papers to his credit.

During World War II, he was primarily concerned with the development of aircraft oxygen breathing apparatus. At the time of his death on March 18, 1946, he was serving Airco in the capacity of Chief Research Engineer in the Apparatus Research Department in Jersey City. Mr. Deming was an Associate Member of the AMERICAN WELDING SOCIETY.

* * *

R. D. Eaglesfield, Sr.

R. D. Eaglesfield, Sr., one of the founders of the Indiana Section of the AMERICAN WELDING SOCIETY and one of the active members thereof, died Saturday morning, March 16th.

Mr. Eaglesfield owned a firm which manufactured special machine tools, farm tools and garden tractors for international distribution and was known nationally for his machinery improvements.

WELDING APPLICATIONS

A very comprehensive and elaborate collection of drawings with explanations in Danish, illustrating various welded constructions is being distributed by Aktieselskabet ESAB, Kjellberg Skolen, Kobenhavn-Valby, Denmark.

BOOK ON RADIOLOGY

"Bibliography on Industrial Radiology, 1942–1945," by Herbert R. Isenburger. Published by St. John X-Ray Service, Inc., Long Island City, N. Y., 1945. Heavy paper looseleaf folder, 9 x 11½ in., 13 pages. Price $1.00. This pamphlet will undoubtedly be well received by many of those interested in or working in this field. It contains over 400 references culled from many American magazines and from some foreign publications. It is published as an addenda to *Industrial Radiology*, second edition, 1943, John Wiley & Sons, New York.

One Rod...

MUREX TYPE U

For All Position Welding With A-C or D-C On Either Polarity

Where several different electrodes are being used for mild steel applications, it will pay you to investigate the all-around usefulness of Murex Type U. Here is a versatile, general-purpose rod designed to meet a wide variety of welding needs—thus eliminating the necessity of purchasing a large number of diversified electrodes.

Type U is primarily a single-pass fillet electrode for use in any position with a-c or d-c on either polarity. It has excellent welding qualities, simplifies slag removal and deposits clean, sound metal with a tensile strength of 70,000 psi.

Complete information, including procedure, application data and physical properties, is available on request. Write today and see for yourself how this one rod can simplify your welding problems.

METAL & THERMIT CORPORATION

120 Broadway, New York 5, N. Y.

Albany • Chicago • Pittsburgh • So. San Francisco • Toronto

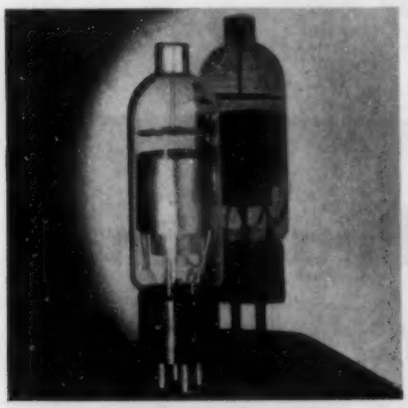
MUREX ELECTRODES

NEW PRODUCTS

The Society assumes no responsibility for the validity of claims in this Section

GRID CONTROL RECTIFIER TUBE

Electrons, Inc., 127 Sussex Ave., Newark 4, N. J., announce a new grid control xenon gas rectifier tube, Type EL C3J. Filament voltage, 2.5 v.;



Grid Control Rectifier Tube

average filament current, 9 amp.; peak forward volts, 750; average d.-c. amperes, 2.5; peak plate current 30 amp.; over-all length, 6 1/8 in. EL C3J is temperature free.

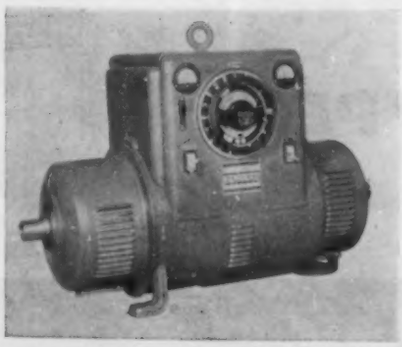
SYNCHRONOUS MOTOR WELDER

By utilizing the inbuilt separate exciter of The Hobart Electric Drive Welder, The Hobart Brothers Co., Troy, Ohio, has produced a compact, high-performing synchronous motor welder. The unit is so proportioned that it can be started across the line and automatically synchronizes itself by the build-up of the separate exciter. The starting current on this unit is approximately the same as a conventional induction motor of the same horsepower capacity.

It is recommended that this unit be operated to draw leading current at no load so as to compensate for other low power factor loads. Welding loads with their high horsepower demand and low duty cycle have long been a problem to Public Utility companies. This unit with its unity or leading power factor characteristics makes it a power saving load, both from the standpoint of the Public Utility and customer.

The motor of this welder is a Hobart revolving field synchronous type. It is furnished with heavy squirrel cage winding to make easy starting as a conventional induction motor. Once up to speed the exciter builds up and automatically applies correct excitation to motor fields.

This machine can also be used as an a.-c. generator for the operation of small tools,



Synchronous Motor Welder

lathes, grinders, etc. This is done by coupling the shaft to a gasoline or electric motor and the synchronous motor then becomes an a.-c. generator.

INDUSTRIAL SAFETY EQUIPMENT

American Optical Co. announces new industrial safety equipment which includes safety goggles, gloves, mittens, a cover mitt, hand pads, a sleevelet, finger cots, spats and ladder shoes. Descriptive literature about the 20 new products can be obtained by writing the company direct at Southbridge, Mass.

The new goggles include a Duraweld goggle for welders; a Duralite goggle for eye protection against flying objects; a chemical goggle; a dust goggle; and a Fits-on goggle for protecting spectacle goggle lenses against pitting and scratching.

The gloves include an open-back glove for women who perform light assembly and bench work; an all-purpose glove for women workers; a heat glove for jobs requiring hot handling; a welder's

Welder Shown Above Wears Some of the New American Optical Safety Equipment

glove; and a glove for resisting rough wear on all-purpose jobs.

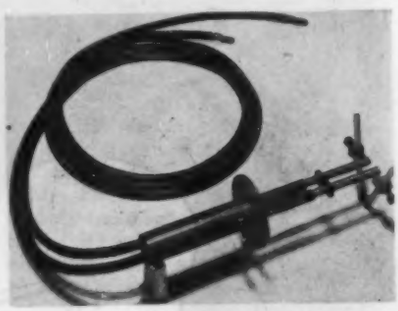
The mittens include a heat mitten especially designed for drop forging, die casting and bending block work; a steel-studded mitten for steel workers; and an asbestos mitten for "heat-treating" operations and for "coil-tying" in steel plants.

The cover mitt fits over gloves and mittens and is designed to add materially to their life while the hand pads are designed to wear over cotton or light-weight leather gloves.

The leather sleevelet provides arm protection on heavy duty jobs; the Sta-Set finger cots protect both front and back of fingers; the two pairs of spats are designed for foundry and chemical workers, respectively; and the ladder shoes prevent accidents caused by skidding or creeping ladders.

TWIN THERMATORCH

The new Twin Thermatorch is now available for use with a.-c. and d.-c. welders and offers the latest in design, workmanship and maneuverability. Built with a uniform, concentric handle it is as natural to grip as an ordinary electrode holder. A single trigger switch, located on the handle, is easily accessible and a simple flip of the finger oscillates one carbon freely for starting, stopping and adjusting arc to proper gap.



Twin Thermatorch

Correct balance and light weight afford ease in operation for continuous welding or heating without arm fatigue. Made of brass, copper and vulcanized fiber the Twin Thermatorch is sturdy, durable and attractive. Suitable for a.-c. and d.-c. machines it permits heating and welding applications not adequately covered with the arc-welding machine alone. Three sizes of carbons may be used 1/4, 5/16 and 3/8-in., with special provisions for larger diameter carbons if necessary. No bushings or adapters are needed for the various sizes of carbons.

Plymouth Equipment & Supply Co., P. O. Box 358, Plymouth, Mich.

OXYGEN AND HYDROGEN IMPURITIES

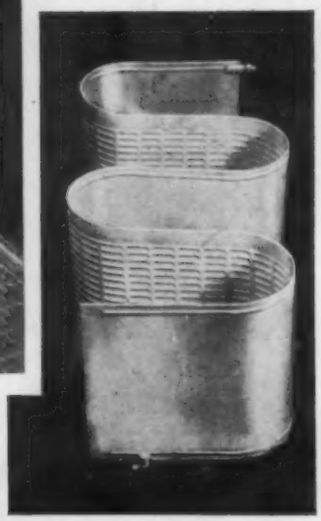
Both oxygen and hydrogen impurities in gases may be detected and measured now through the same instrument which has been designed and constructed by Baker & Co., Inc., Newark 5, N. J.

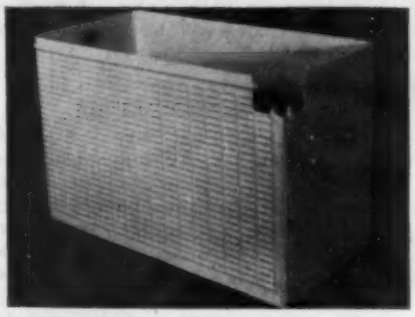
Resistance Welding "by the Mile" Makes Products Like This Possible

ABOVE . . . A long roller table through the throat of the Federal welder makes indexing the plates an easy matter. This plate takes 1600 spots.

•

AT LEFT . . . A similar roller table is used with the Federal seam welder. About twenty-two feet of weld around this plate. When Infra-Red-Baked finish is applied to the plates the welds are not discernible.





The serpentine shaped plate above makes an efficient refrigerating unit for a four-can ice cream cabinet. Square one at left is for a deep-freeze unit. Note the bending these welded fabrications must stand and still be gas-tight.

Seven Federal 75 KVA press type spot welders and two Federal 150 KVA seam welders deliver close to a million spot welds and some five miles of seam weld weekly to produce thousands of feet of Hubbell-Yoder Refrigeration Plate, at the Cleveland plant of The Yoder Company Fabricating Division.

These patented plates make deep-freeze cabinets, refrigerator cars and trucks, ice cream cabinets and frozen food lockers easier to produce, cheaper and more efficient. They are typical of the many useful products which can be manufactured on a practical production basis only because of the fast automatic fabrication that is natural to resistance welding.

Although similar production can be automatically fed, these plates are hand indexed because of the variety of sizes and shapes involved . . . from ten to thirty inches wide, two to ten or more feet long. Two sheets of cold rolled steel are used, one perfectly flat, the other press-embossed with interconnected vertical and horizontal channels.

The two sheets are welded together with spot welds, using three-quarter inch electrodes, located at alternate ends of the flat rectangular areas between channels. Edges and ends are seam welded. Some of the larger plates have more than 2200 spots and 25 feet of seam weld. These must be high quality weld, air tight, tested to 200 pounds pressure.

The Standard Federal welders and equipment used in this production, can be used for an endless variety of ordinary or unusual fabrication. It is worth while to remember that resistance welding may well be the answer in <u>your</u> production . . . that Federal engineers are available to help you find out . . . that in resistance welding the name of authority is

Federal

THE Federal MACHINE AND WELDER CO.

SUBSIDIARIES

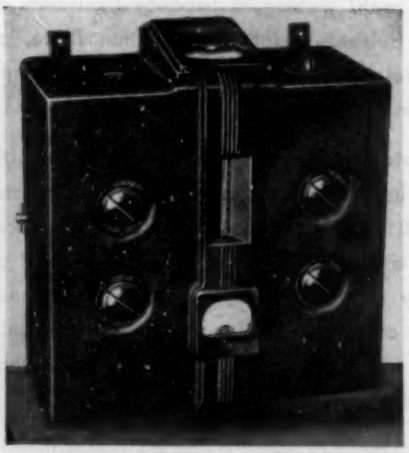
Sommer and Adams Co., Cleveland—SPECIAL HIGH PRECISION MACHINES

The Warren City Mfg. Co., Warren—WARCO PRESSES and PRESS BRAKES

206 DANA ST., WARREN, OHIO

MEMBER RWMA

The instrument, known as the Deoxo Indicator, first announced as providing through a precious metal catalyst "a practical and reliable method" for determining oxygen impurities has since been further refined and now may also be used for testing and measuring the presence of hydrogen in inert gases, nitrogen, carbon dioxide and saturated hydrocarbon gases, Baker & Co. officials announced. When required, the Deoxo Indicator can be furnished with a circular chart type potentiometer recorder and air-operated controller.



Ruggedly constructed and capable of operation for long periods with little or no attention, the manufacturers state the instrument is suited both for industrial and laboratory use. It indicates the presence of from 0.001 to 1.0% oxygen impurities, and tests have shown that the accuracy of indication "may be conservatively estimated at ±2% of the range in use at any time. A means of calibrating the instrument is provided.

In industry the indicator will be useful many ways. It will check "substantial losses resulting from large batches of product spoiled by traces of oxygen in sintering atmospheres; and it will also help to avoid costly spoilage by detecting and measuring any oxygen impurity in the gases used for filling tubes and lamps," the company's literature states. "Minute quantities of oxygen in the atmosphere of heat-treating and brazing furnaces may result in impaired quality, especially when working with stainless and other alloy steels."

ELECTRODE HOLDERS

A complete new line of manual arc welding electrode holders to be known as "Twecotong" has just been announced by the Tweco Products Co., Wichita 1, Kans. The new line includes full-insulated and semi-insulated models.

"Twecotong" is a conventional tong-type holder; however, it features almost indestructible molded-laminated glass cloth Bakelite insulation keyed to the holder casting. Tensioning spring firmly seats on fiber upset washers and is protected from spatter by nonbinding neoprene tubing. Well-ventilated fiber

handle, together with good cable connection, assures a cool running holder. All parts are replaceable.

Full information, together with price and parts list, is included in the 1946 "Twecolog" available from the manufacturer.

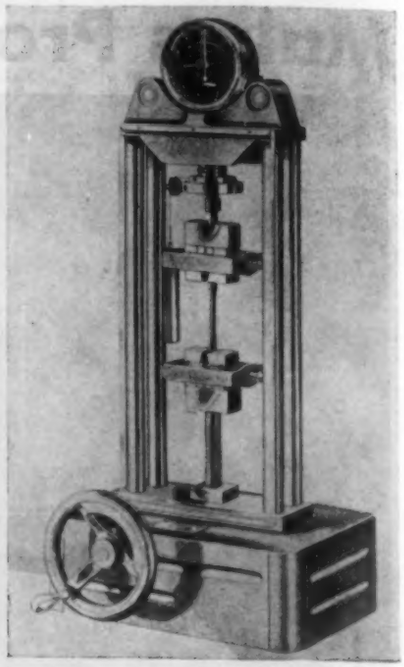
DETECTING FAULTY WELDING

Shipyard Stool Pigeon tattles on false or faulty welding in U. S. Steel's Federal shipyard at Kearny, N. J. This is Federal's newest safeguard against weak seams in prefabricated vessels now being built there. The pigeon is tack welded to a seam to be tested, and an electrically driven saucer-shaped blade cuts out a 3- to 4-in. piece of welding. The pieces

are analyzed for flaws, change in density and physical markings. Subsurface defects are easily detected in this fashion. X-rays likewise are used to spy on internal defects. Welds also are inspected visually for proper size, cracks and other surface defects.

SMALL TENSILE TESTING MACHINE

This new portable testing machine opens the door to quality control. Made by W. C. Dillon & Co., Inc., 5410 W. Harrison St., Chicago 44, Ill., this compact version of its larger brothers weighing thousands of pounds is perfectly suited to tensile or compression testing of steel, wood, plastics, cord, glass, aluminum,



wire, castings, copper, springs and numerous other items. Company states this new tester fills a long-felt need for loads up to 10,000 lb. and is priced well within range of small company budgets.

This instrument is widely used by welding shops, wire shops, plastic makers and almost any type of industrial shop you may think of.

ARCOS OPENS NEW ENGLAND OFFICES

On May 1, 1946, Arcos Corp., manufacturers of stainless and alloy electrodes, began serving the New England States from a new district office located at 450 Asylum St., Hartford 1, Conn.

John K. Light is the Field Engineer in charge and is being assisted by Charles B. Culbert. Both men are well informed on alloy welding problems, having served for a number of years in the Arcos home office organization in Philadelphia. A stock of Arcos electrodes will be maintained in Hartford.

SUSTAINING MEMBER

The Dow Chemical Company, Midland, Michigan, is a vast chemical organization having some eight plants in various parts of the country and manufacturing better than 500 different products. In addition to its own holdings, it operates three government-owned styrene plants and operated two government-owned magnesium plants until the production of the metal was curtailed recently. Pioneered in the development of Magnesium and its fabrication.

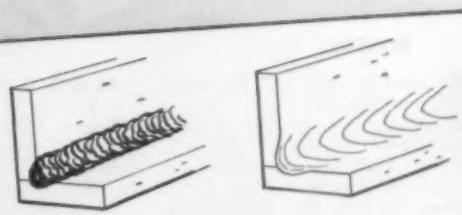
Branch sales offices of this Company are located in New York, San Francisco, Philadelphia, Los Angeles, Washington, St. Louis, Cleveland, Houston, Chicago, Seattle, Detroit and Boston.

FOR HIGH SPEED, HIGH QUALITY WELDING

—USE DH-2

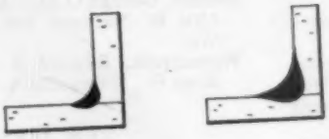
GREATER SPEED

DH-2 is a really fast electrode — for more pounds of deposit per hour, less welding cost. It's easy to handle with minimum spatter loss.



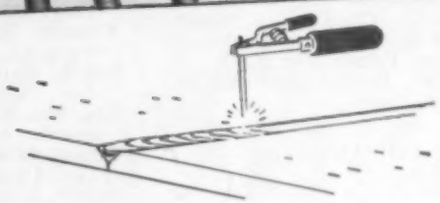
BETTER APPEARANCE

Weld metal "feathers out" — neat and uniform. It eliminates notched effect along weld edge — improves product appearance.



MEDIUM OR DEEP PENETRATION

If you desire medium penetration, you weld at normal amperages. You get deep penetration at high amperages.



FOR DOWNHAND

DH-2 is a "specialist" — designed specifically for horizontal, flat fillet and groove welding — proved the country over.

"SM"	"FR"	"CM-5O"	"FW"	"AC-3"	"PF"	"AC-1"	"AP"
AWS E-6013	AWS E-6012	AWS E-7011	AWS E-6020	AWS E-6013	AWS E-6012	AWS E-6011	AWS E-6010

P&H

HARNISCHFEGER CORPORATION

WELDING ELECTRODES

4551 W. National Ave.
Milwaukee 14, Wis.

SEE P&H—FOR ALL ELECTRODE REQUIREMENTS

DH-2 is one of many types of P&H electrodes which meet every welding need. Above are just a few of the complete P&H mild steel group. Ask for complete line booklet R-7.

AMERICA'S MOST COMPLETE ARC WELDING SERVICE

DC WELDERS · AC WELDERS · WELDING ELECTRODES · WELDING POSITIONERS · WELDING PRODUCTION CONTROL SYSTEMS · ELECTRIC HOISTS

List of New Members

April 1 to April 30, 1946

BOSTON

Haggerty, Bernard P. (B), 153 Norwood Ave., Edgewood 5, R. I.
Kelley, William D. (C), 16 Jewett St., Roslindale, Mass.
Miller, Eric (B), Atom Welding & Repair Co., 88 Broad St., Boston 9, Mass.
Miller, Harvey S. (C), 114 Strathmore Rd., Brookline 46, Mass.

BRIDGEPORT

Hambrook, Roderick H. (B), The Bigelow Co., River St., New Haven, Conn.
Pascale, Martin (B), 1 Lois St., Norwalk, Conn.

CHATTANOOGA

Chambless, Louis S. (C), Combustion Engineering Co., Chattanooga, Tenn.
Harris, Leslie G. (C), Harris Machine & Welding Shop, Pulaski, Tenn.
Kelker, John W., Jr. (C), 1025 E. 9th St., Chattanooga, Tenn.

CHICAGO

Annable, Grant J. (C), 6221 S. Ingleside Ave., Chicago 37, Ill.
Briggs, Fred P. (C), 6221 S. Drexel Ave., Chicago, Ill.
Fox, Charles B., Jr. (C), Machinery & Welder Corp., 1324 W. Fulton St., Chicago, Ill.
Hagberg, Robert E. (C), Machinery & Welder Corp., 1324 W. Fulton St., Chicago 7, Ill.
Leight, Lee W. (C), 3024 N. Linder Ave., Chicago, Ill.
Miletic, Joseph (B), c/o Dube Mfg. Co., 1244 E. 73rd St., Chicago 19, Ill.
Rothschild, Edgar Payne (C), 10459 S. Spaulding, Chicago, Ill.
Simon, Steve J. (C), Dube Mfg. Co., 1244 E. 73rd St., Chicago, Ill.

CINCINNATI

Greiner, Edwin A. (B), c/o Welders Supply & Mfg. Co., 108 W. Central Pkway., Cincinnati 10, Ohio.
Root, Charles W. (B), c/o Welders Supply & Mfg. Co., 108 W. Central Pkway., Cincinnati 10, Ohio.

CLEVELAND

Bushman, Albany (C), 249½ Bath St., Elyria, Ohio.
McOsker, E. J. (C), *The Welding Engineer*, 1510 Hanna Bldg., Cleveland 15, Ohio.
Orland, John B. (C), 14005 Dressler Rd., Garfield Hts., Cleveland 5, Ohio.
Weimer, Roscoe E. (C), Route 1, Glenmont, Ohio.

COLUMBUS

Mars, Lawrence B. (C), 3292½ N. High St., Columbus 2, Ohio.

DAYTON

Abel, C. B. (C), The Sight Feed Generator Co., 14 N. 10th St., Richmond, Ind.
Boner, Clemerd C. (C), 3614 Idylwilde Blvd., Dayton 5, Ohio.
Bowers, William M. (C), 2337 Farrell Ave., Dayton 5, Ohio.
Clark, Harry S. (C), 19 E. Madison Ave., Springfield, Ohio.
Favorito, Charles W. (C), P. O. Box 92, Troy, Ohio.
Garlitz, Russell J. (C), 25 Cardington Rd., Dayton 9 , Ohio.
Howell, William B. (C), Penn Rd. at Westgate, Troy, Ohio.
Howey, Howard J. (C), 14 N. 10th St., Richmond, Ind.
Isgrigg, Gilbert (C), 104 N. First St., Miamisburg, Ohio.
Johnson, Arthur (C), Hobart Bros. Co., Troy, Ohio.
Krueger, Rudolph (C), 7 Alaska St., Dayton 4, Ohio.
Paden, Harold M. (C), 2921 Kenmore Ave., Dayton, Ohio.
Rea, Wm. B. (C), The Sight Feed Generator Co., 14 N. 10th St., Richmond, Ind.
Schaaf, Edward A. (C), 2811 Kennedy Ave., Dayton 10, Ohio.
Snyder, Howard J. (C), 318 Shroyer Rd., Dayton 9, Ohio.
Wehrly, Russell C. (C), R. R. 8, Dayton 3, Ohio.
Wilson, Geoffrey D. (C), Box 51, Casstown, Ohio.
Woods, Robert C. (C), Weiler Welding Co., Dayton 2, Ohio.

DETROIT

Bennett, George (C), 1110 E. 6th St., Royal Oak, Mich.
Coalwell, N. E. (A), General Plant Supt., The Dow Chemical Co., Midland, Mich.
Dill, Homer M. (B), Westinghouse Electric Corp., 5757 Trumbull Ave., Detroit, Mich.
Griswold, Richard F. (C), 9219 Mason Pl., Detroit 9, Mich.

HARTFORD

Parsons, John S. (C), Engineering Dept., The Stanley Wks., New Britain, Conn.
Wagner, Anton J. (C), Dept. of Public Safety, 196 Worthington St., Springfield, Mass.
Werts, D. E. (C), 320 Church St., Hartford, Conn.

KANSAS CITY

Agee, Oscar L. (B), 4218 Waddell Ave., Kansas City 2, Mo.
Coyle, Norman S. (B), 4525 Headwood Ave., Kansas City, Mo.

LEHIGH VALLEY

Libsch, Joseph Francis (C), Lehigh University, Bethlehem, Pa.

LOS ANGELES

Steele, Melba E. (C), 11801 Avon Way, Culver City, Calif.

MARYLAND

Long, M. I. (C), 1101 Key Highway, Baltimore, Md.
Sayre, Harrison S. (C), U. S. Naval Engineering Experiment Station, Annapolis, Md.

MICHIANA

Farmer, Leon C. (C), Studebaker Corp., 1136 S. Main St., South Bend, Ind.

MILWAUKEE

Doerr, Francis X. (C), 6417 W. North Ave., Wauwatosa 13, Wis.
Renner, George O. (C), Renner Mfg. Co., 1504 W. National Ave., Milwaukee 13, Wis.
Wotoszynik, Edward J. (C), 1513 A-W Scott St., Milwaukee 4, Wis.

NEW JERSEY

Duncan, Edward (C), P. O. Box 344, Rahway, N. J.
Freeman, Laurence (C), 65 Christopher St., Montclair, N. J.
Graney, Tom (C), 715 Central Ave., Rahway, N. J.
Hughes, William D. (C), N. J. Welding Supply Co., 270 Central Ave., Newark, N. J.
Klockner, Joseph S. (C), Klockner Steel Prods., Inc., 14 Grafton Ave., Newark 4, N. J.
Komleski, Edward (C), 130 Longfellow St., Carteret, N. J.
Popow, Edward (B), Transit Welding Co., 388 Belleville Ave., Bloomfield, N. J.
Reardon, Clarence E. (C), Glenwild Ave., Bloomingdale, N. J.
Shipnoski, Frank (C), Foster-Wheeler Corp., Carteret, N. J.

NEW ORLEANS

Baugh, J. E. (B), P. O. Box 1762, Monroe, La.
Edwards, O. W. (C), 2200 E. Main St., New Iberia, La.
Tallant, James W. (B), 529 Felicity St., New Orleans, La.

NEW YORK

Askin, James D., Sr. (B), The Hallen Co., Inc., 45-24—37th St., Long Island City, N. Y.
Combes, C. L. (B), *Railway Age*, 30 Church St., New York 7, N. Y.

NORTHERN NEW YORK

Gregory, Claude E. (C), Del. & Hud. R.R. Corp., Car Dept., Oneonta, N. Y.

HIGH INTENSITY SOFT X-RAYS THE MACHLETT AEG-50

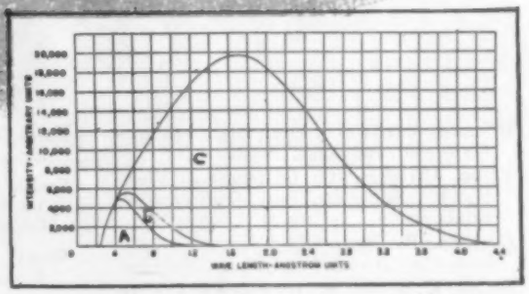
THIS is an announcement of a new Machlett X-ray tube that provides soft X-rays in high intensity. The wave band covered extends from .2475 to 4.4 Angstrom units. See chart.

APPLICATIONS. Microradiography, industrial radiography and fluoroscopy of light materials, and other uses requiring high-intensity soft X-radiation. Examples: Inspection of thin sheets and wires, and of welds in them.

RATINGS. Maximum Voltage: 50 PKV, useful or inverse. Anode at ground potential. Maximum Energy: 20 MA at 50 PKV continuous.

GENERAL. Water-cooled by tap water flowing through ducts in vacuum-cast copper anode. Rayproof. May be operated on either rectified or unrectified volfage. Available in either shockproof or non-shockproof form.

For complete details of this new tube, write Machlett Laboratories, Inc., Springdale, Connecticut.



Wave bands and intensities of X-ray provided through: A, aluminum; B, pyrex glass; C, beryllium

WARNING!

Due to the low inherent filtration of the beryllium window of this tube, its very close proximity to the focal spot, and the high milliamperage rating, the intensity of the radiation at the outer surface of the window may be as high as 1,000,000 R Units per minute. Adequate precaution to avoid the possibility of any person being exposed to this unfiltered radiation, even for an instant, must be taken.

A 50 MA version of this tube offers new possibilities for research on the photochemical effects of X-radiation at intensities in excess of 2,000,000 R Units per minute. Inquiries are invited.

MACHLETT

APPLIES TO INDUSTRIAL USES 1/9 49 YEARS OF ELECTRON-TUBE EXPERIENCE

NORTHWEST

Cox, George E. (C), 232 Marshall Ave., St. Paul 2, Minn.
Kimblin, Ray (C), 1329—6th St. S. E., Minneapolis 14, Minn.

NORTHWESTERN, PA.

Gillispie, Robert L., Jr. (C), 506½ Liberty St., Warren, Pa.
Mattson, J. W. (C), 1207 Rankin Ave., Erie, Pa.

OKLAHOMA CITY

Marks, F. C. (C), 2315 N. W. 34th, Oklahoma City, Okla.
Olson, Leslie (C), 2724 N. W. 16th, Oklahoma City, Okla.

PHILADELPHIA

Collins, John R. (C), Arcos Corp., 1515 Locust St., Philadelphia 2, Pa.
DeHuff, Philip G., Jr. (B), 221 Kathmere Rd., Havertown, Pa.
Mitchell, John E., Jr. (C), Lukenweld, Inc., Coatesville, Pa.
Young, Henry A. (C), K. Wm. Ostrom & Co., 1622 Fairmount Ave., Philadelphia 30, Pa.

PITTSBURGH

Foro, Marshall H. (C), Lincoln Elec. Co., 926 Manchester Blvd., Pittsburgh 12, Pa.
Snyder, Daniel J. (B), Carnegie-Illinois Steel Corp., 615 Frick Bldg., Pittsburgh 19, Pa.

PUGET SOUND

Martin, Gerald E. (B), 2628 12th Ave. N., Seattle 2, Wash.
Shaw, Howard J. (C), 603 3rd Ave., West, Seattle 99, Wash.

ROCHESTER

Schmink, Dean (C), Henrietta, N. Y.

SAN FRANCISCO

Bloedorn, Emil (B), Stone-Ryals Elec. & Mfg. Co., 470 Natoma St., San Francisco, Calif.

SOUTH TEXAS

Cox, Wilburn C. (C), General Elec. Co., P. O. Box 9025, Houston 11, Tex.
Douglas, Lester F. (C), General Elec. Co., P. O. Box 9025, Houston 11, Tex.
Fitch, J. B. (C), General Elec. Co., P. O. Box 9025, Houston 11, Tex.
Nordin, Obert L. (B), Thornhill Craver Co., P. O. Box 1184, Houston 1, Tex.

TACOMA

Healy, Clayton M. (C), 2043 Lincoln Ave., Enumclaw, Wash.

TOLEDO

Rawson, Edward A. (B), R. 10, Box 453, Toledo 12, Ohio.

WESTERN NEW YORK

Bos, William J. (B), Maelou Dr., R. F. D. 3, Hamburg, N. Y.
Skinner, George M. (B), The Linde Air Prods. Co., East Park Dr. & Woodward Ave., Tonawanda, N. Y.
Stouffer, Roger L. (C), Harnischfeger Corp., 901 Dun Bldg., 112 Pearl St., Buffalo 2, N. Y.

WICHITA

McFeeters, John H. (C), 2516 Graham, Wichita 6, Kan.

YORK-CENTRAL PA.

Kauffman, John W. (C), R. D. 1, Holtwood, Pa.
Velardi, Fred C. (C), Naval Ordn. Plant, York, Pa.

NOT IN SECTIONS

Berens, Edmund J. (B), 2950 St. Paul St., Denver 5, Col.
Damme, M. H., Jr. (C), Werkspoor N.V., Amsterdam, Holland.

Members Reclassified

During Month of April

Dilogica, Arthur (B), P. O. Box 34, Times Plaza Sta., Brooklyn, N. Y.
Eaton, Alfred H. (C), 66 Dimsdale View, Porthill, Stoke on Trent, Staffordshire, England.
Gorthon, B. Frederick (C), Gasaccumulator Co., Stockholm, Lidingo, Sweden.
Hume, K. B. (C), K. B. Hume & Co., 16 Keera St., Geelong, Victoria, Australia.
Kann, Charles S. (B), P. O. Box 1071, Shanghai, China.
Rogers, James B. (B), Box 272, Demopolis, Ala.
Roux, Thomas L. (C), c/o Mr. D. Sutherland, 200 Madison Ave., New York, N. Y.
Smith, W. J. Burling (B), 16, Temple Market North, Gatlands Dr., Weybridge, Surrey, England.
Wang, Thomas D. (B), P. O. Box 1071, Shanghai, China.

COLUMBUS

Wingert, Jesse H. (from D to C), 781 E. Southern St., Springfield, Ohio.

LOS ANGELES

Garibay, Joseph (from C to B), 1517 Colegrove Ave., Montebello, Calif.

NEW JERSEY

Hunter, Robert C., Jr. (from C to B), 651 Penn. Ave., Lyndhurst, N. J.

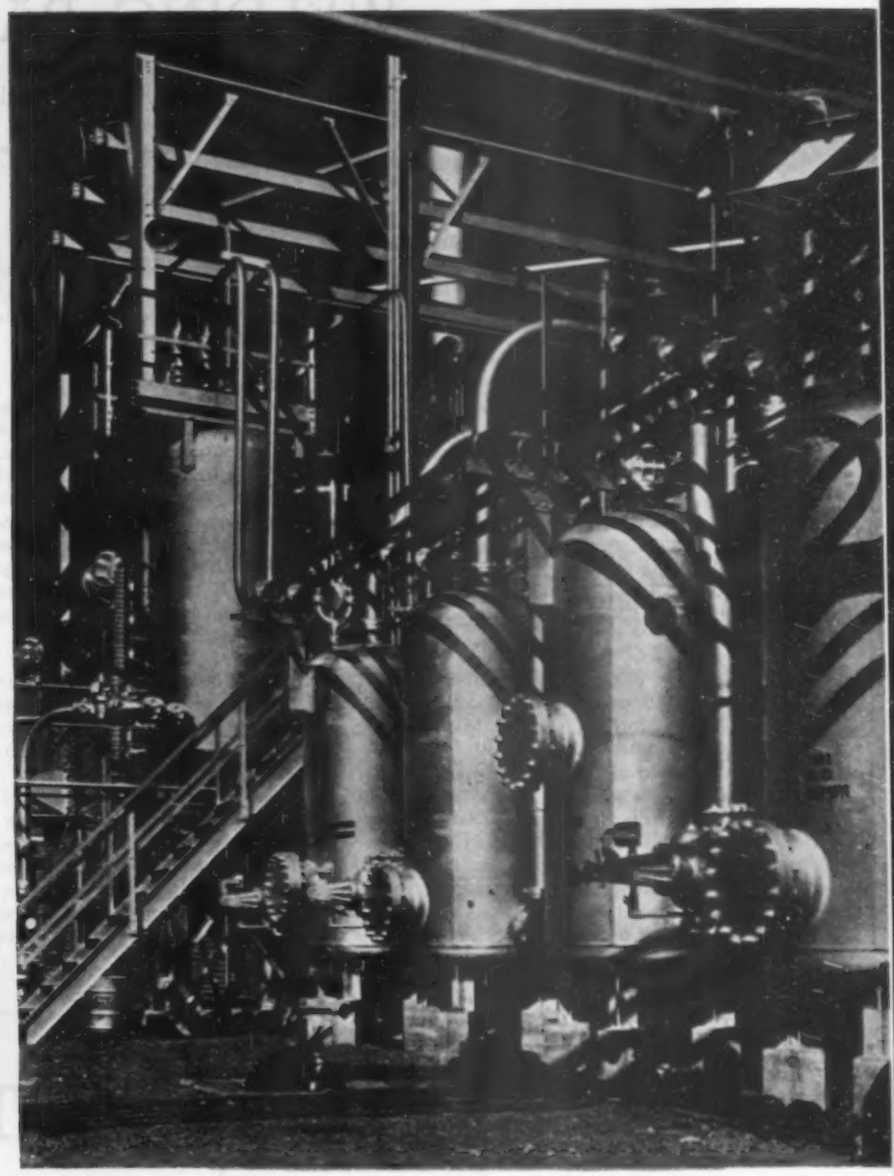
NEW YORK

Posner, Harry (from C to B), N.Y.C.R.R. System, 466 Lexington Ave., Rm. 932, New York 17, N. Y.

1946 YEAR BOOK
AMERICAN WELDING SOCIETY

A limited supply printed. Available to members without charge upon request. Address American Welding Society, 33 West 39th Street, New York 18, N. Y.

Radiographs like this helped create a multi-million dollar business



They can help your welding shop get more business

IF it hadn't been for welding, we might not have had synthetic rubber . . . the plates required for the high-pressure equipment were too thick for riveting.

Because radiography had already sold welding to engineers . . . had convinced the A. S. T. M. that welding should be written into the boiler code . . . the welding industry got the job of fabricating equipment for manufacturing synthetic rubber . . . millions of dollars worth.

And this is only a beginning. Tremendous new construction projects lie ahead . . . tunnels, bridges, building, equipment . . . hundreds of jobs calling for the speed, economy, lightness, and strength of sound welded joints.

NOW IS THE TIME to take a fresh look at radiography . . . to investigate advantages of qualifying *your* shop for any job that comes along. Ask your radiographer or call your local x-ray dealer. They will be glad to discuss your problems with you. Or write to

Eastman Kodak Company, X-ray Division, Rochester 4, New York

Radiography

another important function of photography

Kodak

ABSTRACTS OF CURRENT WELDING PATENTS

Prepared by V. L. Oldham

Printed copies of patents may be obtained for 10¢ from the Commissioner of Patents, Washington 25, D. C.

2,397,519—WELDER HANDLE; William C. Anthony, *Inventor;* Streator, Ill. *12 claims.*

The patented handle includes a jaw which mounts a second jaw with means being connected to the jaws for opening them when no other force is exerted on the jaws. A cylinder and piston assembly is provided between the jaws for moving them in their closing direction when pressure is supplied to the cylinder, and a valve is provided for controlling flow of fluid to the piston assembly. An adjustable bleeder discharge is also included in the handle and connected in the fluid circuit to bleed fluid into the handle to cool it.

2,398,032—ELECTRODE HOLDER; Robert Munro, Grosse Pointe Woods, and Arthur A. Albright, Detroit, Mich., *Inventors. 3 claims.*

This electrode holder has a body with a bifurcated end portion that has registering openings formed in the furcations. Removable inserts are carried in the furcations and have openings therethrough for receiving an electrode while a slide is supported between the furcations and has a hole through it registrable with the openings in the furcations for receipt of an electrode. Spring means engage the slide and normally urge it in a direction as to disalign the hole in the slide and the openings in the furcations.

2,398,884—GAS TORCH; John J. Crowe, *Inventor;* Westfield, N. J.; assignor to Air Reduction Co., Inc. *5 claims.*

This patent relates to a descaling torch having an elongated block which has two rows of gas passages therein that terminate in two rows of discharge orifices. Oxygen is supplied to one row of passages and fuel gas to the other with such gases being mixed by discharge from the torch. All of the passages of one of the rows are of generally Venturi shape.

2,398,937—METHOD OF WELDING TUBE; Raymond H. Hobrock, *Inventor;* Troy Township, Oakland Country, Mich.; assignor to Bundy Tubing Co., Detroit, Mich. *9 claims.*

The tube forming method has reference to the known process of forming a strip of steel stock to tubular shape and welding the adjacent stock edges together by electrodes contacting the stock on opposite sides of the seam formed therein as the stock is moved through a welding throat. The novelty of the patent lies in bonding a metal on the steel stock, which metal has higher electrical conducting properties than the steel stock, and bringing the electrodes into contact with the coated surfaces of the formed tube.

2,398,946—ELECTRIC SOLDERING, BRAZING, AND LIKE TOOL; Hugh Joseph Lorant and John William Bridgland, London, England, *Inventors;* said Bridgland assignor to said Lorant. *2 claims.*

The patented tool is of the contact type and has an electrically conducting body portion, a handle on the body portion, and two electrode receiving holes in the body portion. The electrode holes extend transversely of the body portion at different angles in relation to the body and are in open communication within the body. Longitudinally split metal sleeves for receiving electrodes are detachably received in the electrode holes and engage with each other within the body portion. A securing member is carried by the body portion and adapted to exert a clamping action on the sleeves, which action is transmitted serially to the pair of sleeves in the absence of electrodes in one or both sleeves.

SECTION ACTIVITIES

CANADIAN

The Toronto Chapter held a Ladies' Night on May 6th in the Mining Building, University of Toronto. "The Nature of Speech and Music" was presented by D. G. Geiger, Transmission Engineer, Western Area, Bell Telephone Co. of Canada, Ltd. The purpose of this talk was to describe the physical nature of Speech and Music, and also to indicate some of the requirements imposed upon transmission systems by these characteristics; how speech is produced and its characteristics, and how music and sound are produced and their characteristics.

The Hamilton Chapter held its last meeting of the 1945–46 Series on May 7th at McMaster University. The Canadian Liquid Air Co. Ltd., color-sound film "No Keener Blade" was shown. This film dramatizes the tremendous advances that have been made in Oxygen Torch Cutting during the past 40 years. It graphically portrays the very important part that Oxygen Shape Cutting Machines played in shaping light and heavy steel parts of ordnance during the past six years.

CHATTANOOGA

The Annual Meeting of the Chattanooga Section was held April 26th at the Chattanooga Golf and Country Club. The program consisted of a talk by L. M. Dalcher, a light and well-accepted entertainment and a business meeting.

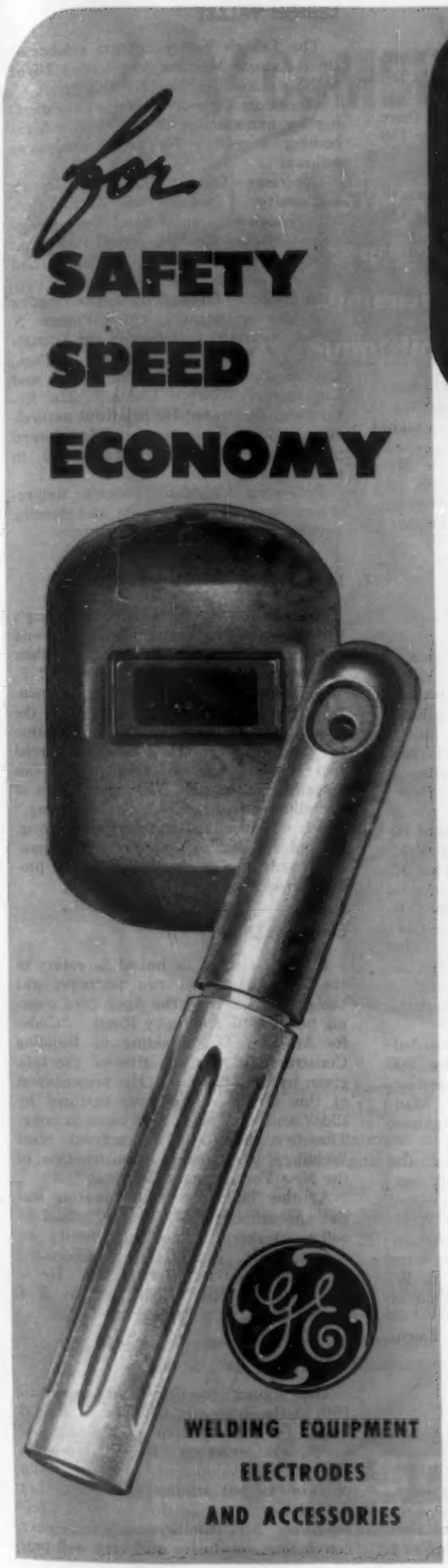
Mr. Dalcher told how the National Office can be of assistance to both Section and individual members with their problems.

At the business meeting the Section election results were announced as follows:

Chairman—H. H. Peek, Lookout Boiler & Mfg. Co.; *Vice-Chairman*—R. E. Brooks, Combustion Engineering Co., Inc.; *Secy.-Treas.*—G. G. Green, National Cylinder Gas Co.; *Executive Committee*—A. J. Moses, J. W. Brown, P. H. Stuff, H. B. Henegar and R.G. Wilson.

CINCINNATI

Regular meeting of the Cincinnati Section was held on Monday, April 22nd, at the Engineering Society Headquarters. L. M. Dalcher, Technical Secretary of the AMERICAN WELDING SOCIETY, was the



Use these G-E WELDING ACCESSORIES Tested and Proved In Many Plants

VENTILATED HELMETS

These helmets afford an extra margin of safety by incorporating an extended skull guard to protect the head and neck from falling objects, such as electrode stubs. Complete with free-floating hinged headgear and adjustable chin rests. Cat. No. 87X578. Many other popular types also available.

LENSES AND COVER GLASSES

Welder's treated cover glass, a product of G-E research, outlasts untreated glass as much as 15 to 1. The tough, transparent, moisture-proof coating maintains clear vision and resists injury and deterioration. Cat. No. 98X349.

ELECTRODE HOLDERS

Completely insulated, this light-weight electrode holder is encased in a sheath of aluminum armor for safer, cleaner, cooler operation. Cat. No. 279X17. Also available are the complete line of Jackson, Duro, and Eureka holders, and electric carbon torch.

WELD-SPATTER-RESISTANT COMPOUNDS

In addition to the popular G-E 1294 (Glyptal), these new water-mixed powder-type compounds have recently been developed. They speed operations by preventing the adherence of weld-spatter to the work and can easily be removed with a damp cloth. They cannot burn nor smoke. No fumes, no oxidation. Thoroughly tested. Cat. No. 9951–9952.

The complete G-E line of accessories includes welding gloves and mittens, chrome-leather protective clothing, flame-proofed curtains, cable connectors, work and ground clamps, Strike-easy compound, weld gages, brushes and chippers, etc. Obtainable at your G-E Welding Distributor—or write for catalog GEA-2704E. General Electric Company, Schenectady 5, N. Y.

GENERAL ELECTRIC

dinner speaker. Mr. Dalcher spoke on the many activities of the Technical Department and urged members to take advantage of the information which this department is in a position to furnish. Guest speaker was Rudolf Kraus, Welding Engineer, Stacey Brothers Gas Construction Co. Mr. Kraus spoke on "Welded Gas Holders of Panel Type." Music during the dinner was furnished by Julius Bergman and his son.

CLEVELAND

The Seventh Regular Meeting was held on Wednesday, April 10th, at The Cleveland Engineering Society. George L. Snyder, Assistant Manager, Development Engineering, Lukens Steel Co., presented an illustrated talk on "How to Avoid Welding." Coffee Talk was given by Marie Stevens, Chairman, Public Relations Committee. Mrs. Stevens spoke on "Possibilities Unlimited."

The Annual Conference of this Section was held at the Hotel Cleveland on Friday, May 10th.

An afternoon technical session followed by a dinner and evening meeting drew over 500 welding engineers and production men from northeastern Ohio.

Headlining the evening meeting was the noted humorist and writer, Strickland Gillilan, who is often called the dean of Washington correspondents. Mr. Gillilan spoke on "The American Way of Life."

The opening speaker of the afternoon technical session, which began at 2 P.M. in the Empire Room, was Dr. I. A. Oehler, Director of Metallurgy and Research for the American Welding and Manufacturing Co. of Warren, Ohio. Dr. Oehler spoke on "Flash Butt Welding of Nonferrous Materials."

C. B. Voldrich, supervisor of Welding Research at the Battelle Memorial Institute, Columbus, Ohio, gave the second technical paper of the afternoon session. Mr. Voldrich spoke on "Hydrogen in Metal Arc Welds."

As the final speaker on the afternoon program, Harold O. Jones of the Air Reduction Sales Co. spoke on "The Future in Mechanical Gas Welding."

The Cleveland Section was proud to welcome our National President, Dr. Wendell F. Hess, to the Annual Conference. Dr. Hess spoke at the dinner.

Toastmaster for the evening meeting was M. M. "Irish" Kenneally, Sales Manager for Joslyn Manufacturing & Supply Co. in Chicago. Chairman of the afternoon session was George N. Sieger, President and General Manager of the S-M-S Corp. in Detroit, and Second Vice-President of the AMERICAN WELDING SOCIETY.

COLUMBUS

The May meeting of this Section was held on the 10th at the Southern Hotel. Dinner speaker was W. H. Heinberger, Plant Engineer; Technical speaker William Reynolds, Aluminum Co. of America. Subject was "Aluminum Welding and Movies."

DAYTON

The Dayton Section held its last meeting of the season at the Engineers' Club on Wednesday, April 24th. It was the largest meeting yet attempted and there was an attendance of approximately 150 members and guests.

Speaker was John H. Van Deventer, President and Editorial Director of *Iron Age*, who spoke on "Let's Take Off the Brakes." His talk as expected, was, interesting and covered not only existing OPA policies but also covered present engineering, labor and management practices. After his address a question and answer period took place, which finally had to be discontinued due to the late hour.

Louis Polk, President of the Sheffield Corp., Dayton, acted as honorary chairman for the meeting. Prior to the main address, a dinner was held at the Engineers' Club with 42 in attendance, where Mr. Polk spoke extemporaneously of his recent visit to the Aberdeen Proving Ground of the U. S. Ordnance Department.

DETROIT

Third Annual Welding Conference of the Detroit Section and Saginaw Valley Division held on Friday, May 10th was a grand success. An enthusiastic audience of 150 attended the afternoon session at the Engineering Society of Detroit. Technical Chairman was G. S. Mikhalapov, Manager, Apparatus Research Dept., Air Reduction Sales Co.

The talks and motion picture listed below were well received. "Automatic Welding in the Automotive Field," by Paul M. Corp, Welding Engineer, American Metal Products Co.; "Electro Brazing," by J. R. Wirt, Welding Engineer, Delco Remy Div., General Motors Corp.; "Resistance Welded Tubing," by Thomas J. Crawford, Consulting Engineer; "Welding Arcs," A Study of Welding Arcs, shown through the courtesy of Reid-Avery Co., Inc.

The banquet held at the Wardell-Sheraton Hotel was attended by 300 people. An exceptionally able Toastmaster was W. B. (Monty) Montague, Manager, Sales Promotion Div., Westinghouse Electric Corp.

"Stratovision, Television from the Stratosphere," a most interesting talk, supplemented by colored slides, was presented by L. S. McLeod, District Manager, Westinghouse Electric Corp.

Dinner music and entertainment were furnished through the courtesy of R. W. (Dick) Lewis of the Stainless Ware Co. of America.

A song fest followed with Bill Townsend as leader.

HARTFORD

At a dinner meeting held on April 18th at The Garde Hotel, John W. Mortimer, Welding Engineer of Whitlock Mfg. Co., Hartford, spoke on "Fabrication of Ferrous and Nonferrous Pressure Vessels."

LEHIGH VALLEY

The Lehigh Valley Section celebrated their Annual Meeting and Ladies Night on May 6th at the Hotel Bethlehem.

Chairman Kenworthy opened the meeting by announcing the Officers and Incoming Directors for next season, as follows:

Chairman—Gilbert E. Doan, Lehigh University; *Vice-Chairman*—C. L. Kreidler, Lehigh Structural Steel Co.; *Secy.-Treas.*—Julius Naab, Ingersoll-Rand Co.; *Incoming Directors*—K. H. Philipp and C. A. Smith.

In honor of Ladies Night, the meeting was strictly nontechnical. William S. LaSor, Assistant Professor in the Department of Religion, Lafayette College, Easton, Pa., spoke on "The People and Customs of Western China." The lecture was illustrated by beautiful natural-color slides. Some of the slides showed places never before photographed in natural color.

Following Chaplain LaSor's well-received lecture, refreshments and dancing were enjoyed until midnight.

LOS ANGELES

The Los Angeles Section met at Scully's Cafe, Thursday evening, April 18th, and were particularly honored to have as their speaker of the evening, Dr. Wendell F. Hess, President of the AMERICAN WELDING SOCIETY. Dr. Hess summed up the activities of the SOCIETY for the duration of his term. Dr. Hess made a special trip to the Coast to talk to the Los Angeles Section on "The Application of Metallurgical Principles to Welding," which was technical and very interesting. He pointed out very clearly how laboratory results can be applied to regular production welding.

LOUISVILLE

L. M. Dalcher, Technical Secretary of the AMERICAN WELDING SOCIETY, was the guest speaker at the April 23rd meeting held in the Kentucky Hotel. "Codes for Arc and Gas Welding in Building Construction" was the title of the talk given by Mr. Dalcher. His presentation of this timely subject was featured by slides and two motion pictures in color. The first film was "Structural Steel Welding," the second "Construction of the New York Airlines Terminal."

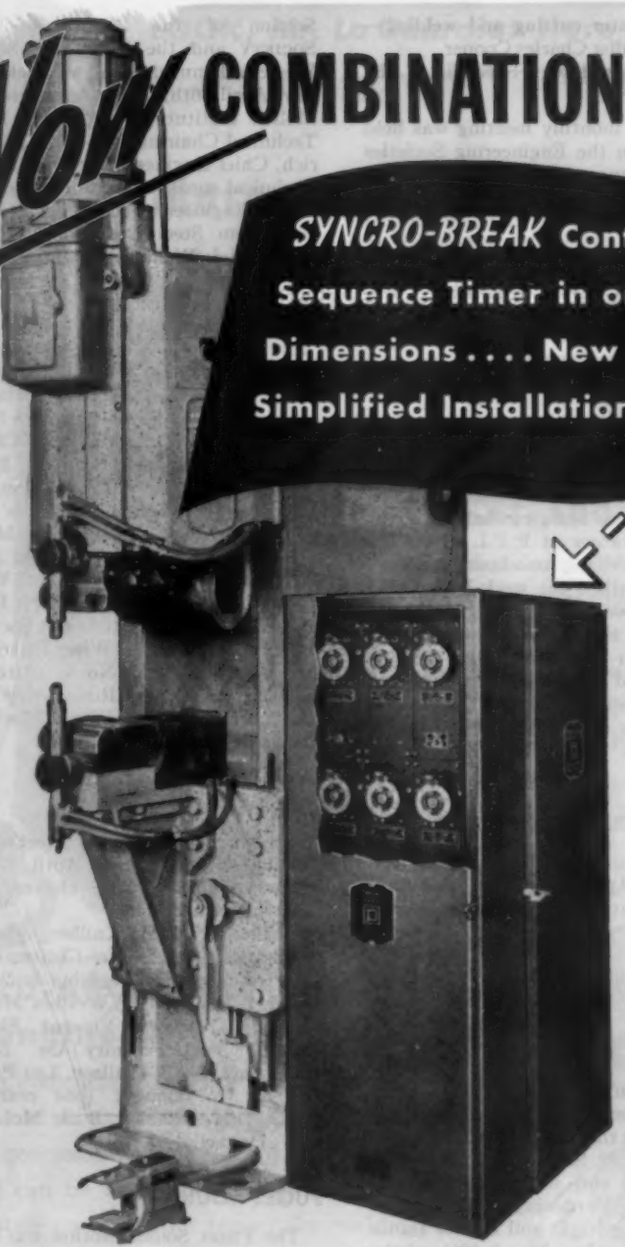
Another highlight of the meeting was the appearance of R. E. McFarland as coffee speaker. A noted authority on welding, Mr. McFarland is associated with the Western Electric Co. He is also Vice-President of District No. 5 of the SOCIETY.

MARYLAND

The dinner meeting held on April 16th at the Engineers' Club was addressed by J. H. Humberstone of the Arcrods Corp., who spoke on "Recent Trends in Electrode Development." A color film of slow motion studies of metallic arc was shown in connection with the presentation. Mr. Humberstone's facts were convincing, conclusive and very well pre-

Now COMBINATION WELDER CONTROL

SYNCRO-BREAK Contactor and *Safront* Weld Sequence Timer in one enclosure .... Standardized Dimensions .... New Safety Features .... Greatly Simplified Installation .... Improved Appearance



1. Complete automatic control system in one cabinet—necessary control fuses, terminals, transformers, etc. included.
2. Specifically designed to meet new standards and recommendations of RWMA and machinery builders.
3. Front location puts dials within easy reach to facilitate machine set-up or time adjustments.
4. Depth standardized at 20 inches, width kept within 15 inch maximum.
5. Foot switch, pressure switch, no-weld switch and timer control circuits are 110 volts for added operator safety.
6. Panel space provided for low voltage control or two-position foot switch auxiliaries.

Safront panel swung out to show timing and sequencing relays. Adjusting dials are on front of this panel for maximum safety. Separable connector strip allows easy removal of panel for installation or maintenance.

Side door gives access to contactor, control fuses, and all line, load, and control terminals. *SYNCRO-BREAK* rheostat is mounted on extended bracket to bring adjusting knob out beyond live parts.

for complete information, write Square D Company, 4041 N. Richards Street, Milwaukee 12, Wisconsin

SQUARE D COMPANY

DETROIT • MILWAUKEE • LOS ANGELES

sented and established beyond reasonable doubt the effect of hydrogen in metallic arc welding.

MILWAUKEE

The regular meeting was held on April 26th at the Ambassador Hotel. After-dinner program consisted of a movie entitled "Electronics," and the welding address by J. M. Diebold, Welding Engineer, General Motors Corp., who spoke on "Fusion Welding of Sheet Metal."

NEW JERSEY

A joint meeting between the Metropolitan Section, New Jersey Division of the American Society of Mechanical Engineers, and the New Jersey Section of the AMERICAN WELDING SOCIETY, was held on Tuesday, April 16th. An inspection trip to the Tidewater Associated Oil Co. Refinery, Bayonne, was held at 2:00 P.M. Members and their guests were able to see in operation a large Fixed Bed Cracking Unit and a very new Thermofor Catalytic Cracking Unit, also the largest heat turbine now in service.

The technical meeting was held in the evening preceded by a dinner at the Essex House, Newark. George W. Nigh of the Tidewater Co. acted as chairman. Speaker was George Kelso, Manager, Technical Service and Plant Operations Div., Houdry Process Corp. Mr. Kelso spoke on the "Houdry Fixed Bed and T.C.C. Catalytic Cracking Processes." The purpose of the talk was to discuss the important role played by mechanical and welding engineers in the design and fabrication of equipment used for these processes.

NEW ORLEANS

Leslie F. McPhee, Superintendent of Welding, Whiting Corp., Harvey, Ill., spoke on "Welding as It Affects Design," at the April lst meeting held in the Isaac Delgado Trades School.

NEW YORK

An inspection trip to the Metal and Thermit Laboratories, Woodbridge, N.J., was made on Saturday, April 27th. Actual welding activities were carried out by skilled technicians under the supervision of qualified specialists and a consultant, who answered questions. Seven different stations were in operation simultaneously, demonstrating the following processes and tests:

1. All-position welding, every type and joint —mild steel—Consultant J. Lyle Wilson.
2. All-position welding, every type and joint —low-alloy steel—Specialist E. Vom Steeg.
3. All-position welding, every type and joint—stainless steel—Specialist H. O. Klinke.
4. Tensile and Navy bend test — Specialist R. C. Pearson.
5. X-Ray and Gamma Ray inspection—Specialist H. R. Isenburger.
6. Underwater cutting and welding—Specialist Charles Cooper.
7. Thermit welding—Specialist J. H. Deppeler.

The regular monthly meeting was held on April 9th in the Engineering Societies Building. Dinner, as usual, preceded the meeting at the Engineers' Club. Walter Begerow, Development Engineer for the Air Reduction Sales Co., presented an address on "Modern Developments in Oxyacetylene Cutting Machines." The talk was illustrated with slides and motion pictures. An electric eye tracing device was shown in actual operation.

NORTHERN NEW YORK

April meeting was held at R.P.I., on the 25th. Messrs. Wyant, Nippes, Savage, Winsor, Doty and Childs described the research work being carried on by the Welding Laboratory at R.P.I. In a full but very interesting two-hour program, each man described the work he is doing and later demonstrated some of the results. All of the members and guests were taken on a tour of the Welding Laboratory and the other laboratories in the Metallurgical Building. The meeting, which was the best attended of the year, was one of the more interesting meetings also.

NORTHWESTERN PENNSYLVANIA

The regular monthly meeting was held on Thursday, April 25th at the Y.W.C.A. This was a joint meeting with the American Society for Metals. R. D. Thomas, Jr., Executive Vice-President of Arcos Corp., Philadelphia, spoke on "Stainless Steel Welding."

PEORIA

One of the outstanding meetings of the year held by the Peoria Section took place on April 17th at the Jefferson Hotel. W. J. Jackel of the A. O. Smith Corp., presented a very timely and interesting talk on "Welding of Air-Hardening Steels."

Annual Ladies Night and Dinner Dance was held on Saturday, March 16th, at the Jefferson Hotel.

PHILADELPHIA

The following officers and executive committee were elected at the April 15th meeting held at the Engineers' Club.

Chairman—Harold B. Seydel, *Vice-Chairman*—E. R. McClung, *Treas.*—Wm. F. Carson, *Secy.*—K. W. Ostrom, *Past Jr. Chairman*—A. A. Holzbaur.

Term Expires 1947—Harry J. Irrgang, O. C. Frederick and J. D. Bert; *Term Expires 1948*—Harry W. Pierce, A. B. Gordon and R. D. Thomas, Jr.; *Term Expires 1949*—A. J. Raymo, G. R. Johnson and W. E. Hendricks.

Roger W. Clark of the Works Laboratory, General Electric Co., Schenectady, N. Y., spoke on "The Engineers Responsibility in the Application of Welding."

PITTSBURGH

Ninth Annual Tri-State Welding Conference sponsored by the Pittsburgh Section of the AMERICAN WELDING SOCIETY and the Engineers' Society of Western Pennsylvania, was held on Friday, April 26th, in the Auditorium of the Mellon Institute of Industrial Research. Technical Chairman was Dr. C. F. Goodrich, Chief Engineer, American Bridge Co. Technical speakers were Jonathan Jones, Chief Engineer, Fabricated Steel Div., Bethlehem Steel Co., and C. B. Voldrich, Chief Welding Engineer, Battelle Memorial Institute. Mr. Jones spoke on "Weldable Structural Steel;" Mr. Voldrich on "The Heat Affected Zone in Steel Weldments."

The Twenty-Fifth Anniversary Dinner followed at Hotel Webster Hall. The presentation of Past-Chairman Pins was made by W. W. Reddie, Past-Chairman, 1927–30, Pittsburgh Section. Brief addresses were made by the following: T. D. Jolly, Vice-President, Engineers' Society of Western Pennsylvania; M. M. Kelly, Secretary, AMERICAN WELDING SOCIETY; W. Spraragen, Editor, THE WELDING JOURNAL; J. H. Deppeler, President of A.W.S. at time Pittsburgh Section was organized, and B. L. Wise, District Vice-President of District No. 4. After-dinner speaker was "Rosey" Rowswell, who spoke on "Laughing at the Clouds," which was very well liked.

PORTLAND, OREGON

At the regular Annual Meeting of the Portland Section held April 25th, the following officers were elected for the following year:

Chairman, Paul Kullberg, Industrial Specialties Co.; *Vice-Chairman*, Paul Chatterton, J. E. Haseltine & Co.; *Secretary*, J. H. Crumley, Western Machinery Corp.; *Treasurer*, Vincent Shanahan, Electric Steel Foundry Co. *Directors:* (two years) G. B. Wallace, Leo Peznecker and T. J. Maloney; (one year) Leslie Poole, J. H. Crumley, B. A. McLean and J. W. Donnelly.

PUGET SOUND

The Puget Sound Section was honored to present Dr. Wendell F. Hess, President, A.W.S., at their April 23rd meeting held at the Engineers' Club, Seattle. Dr. Hess spoke on the subject of Resistance Welding.

ROCHESTER

The May meeting was held on the 2nd at the Century Sweet Shoppe. Entertainment was furnished by Professor Ruda, Doctor of Buffoonery. Movies: "Making Money," "Vera Cruz," "Yes, Bananas," were shown. A buffet lunch was served at 10:00 P.M.

SAINT LOUIS

The St. Louis Section held its April Technical Meeting on the 12th at the Engineers' Club. P. J. Patton of the Ransome Machinery Co., spoke on "Development and Application of Welding Positioners," which was supplemented very neatly by a powered model positioner which was a unique method of conveying

LOOK, Mr. La Guardia: **Here is important news affecting many industries:**

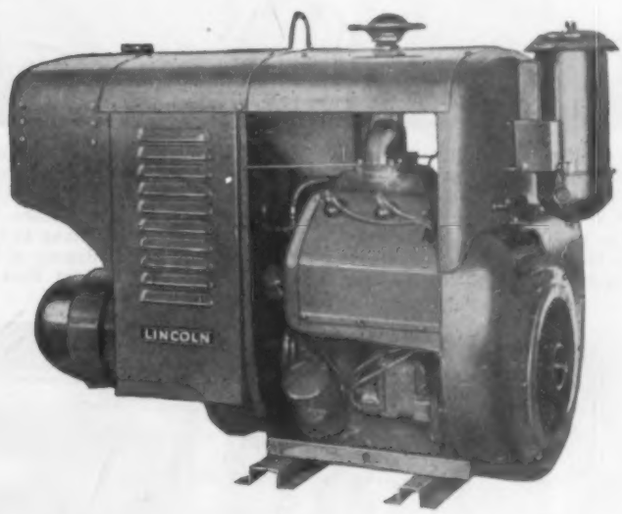
More and more people will use arc welding *because of these* 2 SENSATIONAL NEW WELDERS

"FLEET-ARC JR."...with the easy-striking arc

Revolutionary "Arc Booster" of this New Lincoln A.C. Welder makes arc-striking as simple and quick as striking a match on a hot stove. Easier than ever to weld all thicknesses of metals, repair broken parts, reclaim worn parts, hard-face. Continuous current control provides exact arc heat for every job . . . range 20 to 180 amps. For standard 230-volt, single-phase power supply. Extremely low price. Full details in Bul. 365, free on request.

"SHIELD-ARC JR."... low-priced engine driven welder

Here is a complete 200-amp. engine driven welder for portable service that's priced as low as many welding generators alone! Compact. Weighs only 660 lbs.; can be easily hoisted into pick-up truck or mounted on a simple trailer for welding duty anywhere. "Job Selector" adjusts welding current by varying engine speed, minimizing fuel consumption. Range 40 to 250 amps. 4-cylinder, air-cooled engine. Full details in Bul. 367, free on request.



THE LINCOLN ELECTRIC COMPANY • DEPT. 53 • CLEVELAND 1, OHIO

America's greatest natural **recourse**

ARC WELDING

the subject. An active discussion session followed.

SAN FRANCISCO

The San Francisco Section held its April dinner meeting at the Engineers' Club. Approximately 60 members attended to hear Dr. Wendell Hess and to honor the past-chairmen of the San Francisco Section.

Following a brief business meeting and election of the Section officers for the coming year, Dr. Hess reviewed the current activities and problems of the AMERICAN WELDING SOCIETY.

Chairman Leo Berner called on the nine past-chairmen who were present, each of whom traced the development of the San Francisco Section during his term.

In his talk on "The Application of Metallurgical Principles to Welding," Dr. Hess showed how the data gathered in research work at Rensselaer Institute together with the metallurgists isothermal transformation or "S" curves can be used to determine a satisfactory welding procedure for a particular steel. In addition, Dr. Hess mentioned several developments and trends in the resistance welding field.

SOUTH TEXAS

The South Texas Section held a regular meeting at the Houston Y.M.C.A. on Tuesday night, April 16th, and members present heard a very interesting and instructive discussion of "Practical Metallurgy as Applied to Welding." Chas. H. Shapiro, of the Metal Carbides Co. of Texas, was the speaker of the evening, and his remarks stressed the need for control standards in the application of welding. The speaker's remarks were followed by a very lively floor discussion with all members present participating.

YORK-CENTRAL PENNSYLVANIA

Before a group of over 400 A.W.S. members, their wives and guests, W. J. Connelly, Manager of the Consumer Relations Div. of Bakelite Corp., New York, told of plastics in our world today. Speaking on the evening of April 3rd at the annual meeting of the York-Central Pennsylvania section of the AMERICAN WELDING SOCIETY, held in the Valencia Ballroom, Mr. Connelly said, "The Plastic Industry does not look upon plastics as cure-alls.

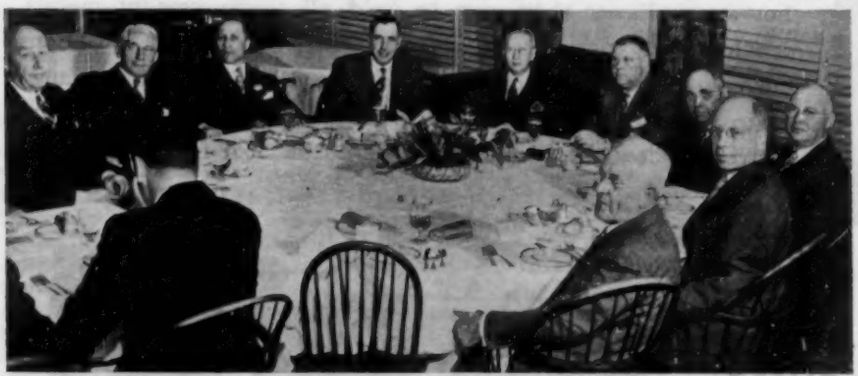
"Plastics have brought to industry many materials with properties never before obtainable with the traditionally natural materials of industry, such as iron, wool, cotton and glass. However, plastics can also assist and augment these natural materials, resulting in a superior product." He illustrated his point by saying the superior type shatterproof safety glass is only possible when glass and plastics are combined in a sandwich type construction.

Explaining that the Plastic world was divided into two basic types of materials: thermoplastics which can be softened by heat and thermosetting materials which broaden and set when heated, he illustrated the various points of his talk from a 12-ft. table piled high with samples of both types of materials.

Of particular interest to the SOCIETY members was the "welding" of plastics, a process which had been used to fabricate many of the verylite plastic applications he displayed. The process, called heat sealing, seals verylite film and sheeting together much like a sewing machine sews cloth together, except that there is no thread and heat is used instead. The material is sealed or fused together in bonds stronger than the material being bonded.

Some of the samples shown by Mr. Connelly that had been heat sealed were verylite pillows, raincoats and a feather light beach ball. He first tossed the beach ball out to the audience and then to illustrate its strength had a young lady sit on top of it.

Ending his talk after displaying a group

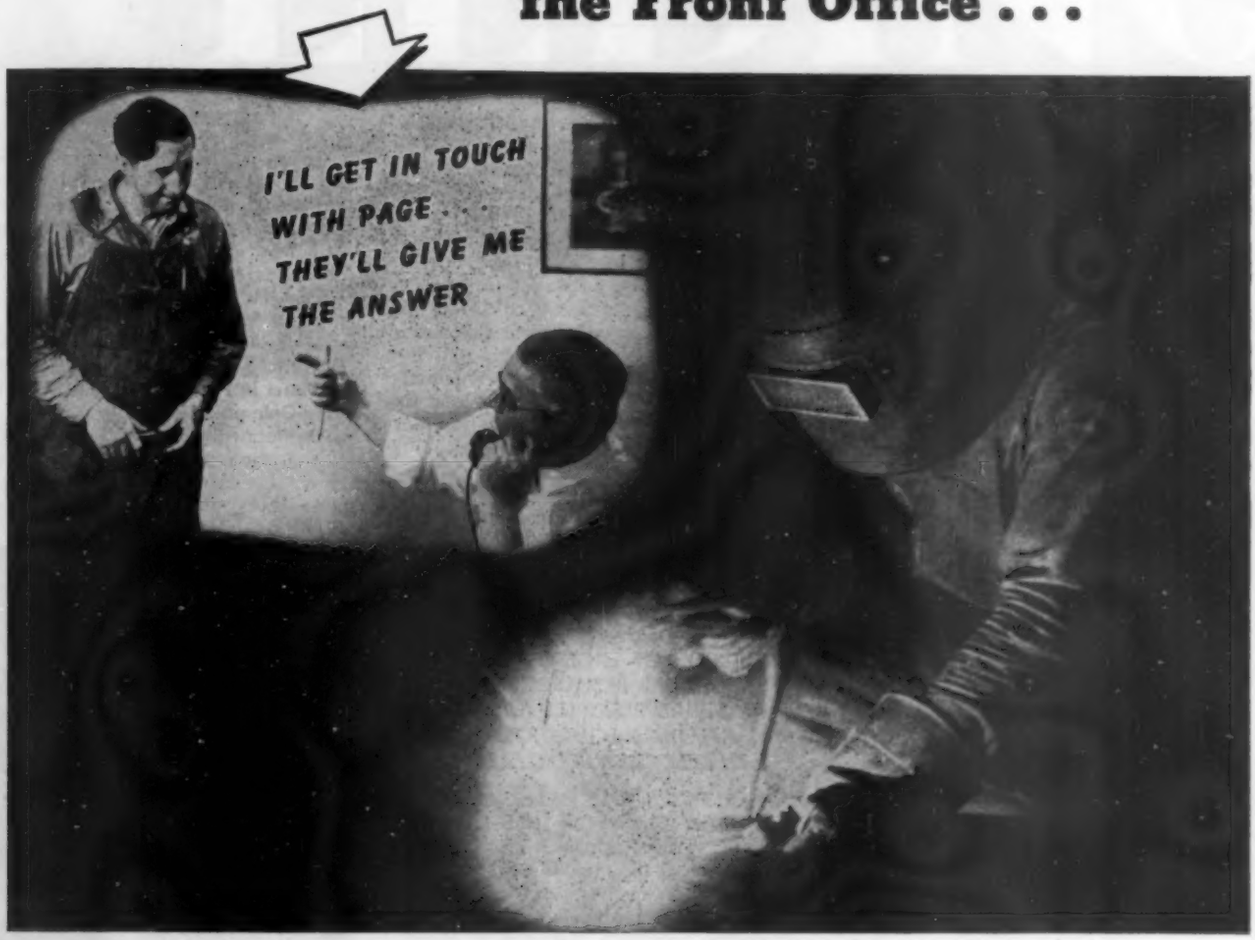


Speakers' Table (Past-Chairmen's Night): Lee W. Delhi, Past-Chairman, San Francisco Section and Former Director-at-Large, A.W.S.; R. O. Waldman, Past-Chairman; Ernest Mathay, Past-Chairman; Harold Chaney, Past-Chairman; Dr. Hess, President, A.W.S.; Leo Berner, Retiring Section Chairman; Mark Haines, Section Chairman Elect; C. S. Smith, Past-Chairman; K. V. King, Past-Chairman and Director-at-Large, A.W.S.; J. C. Bennett, Charter Member and First Chairman of the San Francisco Section; (Vacant) Frank Longo, Past-Chairman and District Vice-President, A.W.S.

York Central Annual Dinner

PAGE *Welding* ELECTRODES

Welding Economy Begins in the Front Office . . .



The right electrode . . . correct welding technique—these add up to economy in production welding. Page offers both: A complete line of electrodes and gas rods (with emphasis on PAGE-Allegheny stainless steel)—plus the benefit of the experience of PAGE selected distributors and PAGE Service Engineers. For uniformly high quality electrodes and rods and information about their most efficient use—get in touch with your PAGE distributor.

ACCO

Monessen, Pa., Atlanta, Chicago, Denver, Detroit, Los Angeles, New York, Philadelphia, Pittsburgh, Portland, San Francisco, Bridgeport, Conn.

PAGE STEEL AND WIRE DIVISION
AMERICAN CHAIN & CABLE

TRADE MARK

of sample of verylite plastics which had been applied to the latest styles of shoes, handbags and umbrellas, Mr. Connelly said, "In every phase of our world today, modern engineering and science are applying plastics to the betterment of our industry, our homes and our everyday lives."

The theme of the evening's meeting was centered around the women who made the banquet such a success last year. In addition to Mr. Connelly's talk the program included an old-fashioned turkey dinner, group singing led by Husky Hoffman, awarding of the door prizes by Charles Allen and the dinner meeting was in charge of W. C. Bauer, chairman of the local section.

E. R. Broden, manager of the Special Ordnance Division, Blaw-Knox Co., was host to the following honor roll members and their wives of the York-Central Section: Edward J. Brady, William J. Fisher, Edward H. Fisher, Harlowe Hardinge, Stewart Lauer, Ben. Root, Samuel H. Shipley, Beachamp E. Smith, William Stair, F. F. Symington and John I. Spangler.

R. S. STOVER PROMOTED

R. J. Thompson, General Sales Manager, Ampco Metal, Inc., Milwaukee 4, Wis., has announced the appointment of R. S. Stover, as Supervisor, Philadelphia–Washington District with headquarters in Philadelphia at the Wilford Building. Mr. Stover previously had been District Manager of Ampco's Washington, D. C., office. Elmer E. Whitson will remain as Philadelphia District Manager. Mr. Stover is a member of the AMERICAN WELDING SOCIETY.

Employment Service Bulletin

SERVICES AVAILABLE

A-520. Assistant Welding Engineer on development work and welding procedure. Has traveled for employer on trouble jobs. Also capable of selling welding equipment and supplies. Would prefer Michigan vicinity, but would seriously consider other localities. Experience includes two years in Welding Engineering; two years Welding Instructor and Welding Supervisor; six years as Welding Operator on Structural Steel and Pipe Fabrication; three years apprenticeship in welding and machine work.

A-521. Welding Engineer, age 30. Bachelor of Science Degree. 10 years' experience in welding and steel industries. Thoroughly experienced in all phases of manual and automatic welding and gas cutting, inspection, planning, production and cost control. Part time in research for last two years and would also be interested in position in this field. Can supply best references on past work. Interested in any of the following locations: Los Angeles, San Francisco, Chicago, New York.

A-522. Interested in Welding Sales. Five years' experience in welding, having worked in numerous job shops, on construction jobs doing pipe and boiler welding and qualified as a high pressure pipe welder. Two years college. Recently discharged from the Armed Forces.

POSITIONS VACANT

The Technical Industrial Intelligence Branch, Commerce Building, Washington 25, D. C., has been asked to obtain the services of a large number of engineers to go to Germany to select documents of importance to American industry. The primary qualifications for this work are a technical education and background, and the ability to read technical German with reasonable facility. Salaries will range from approximately $3800 to $5180 per annum, depending on previous experience and qualifications, plus adequate living allowance and transportation. The minimum assignment will be for at least six months. It is pointed out that where a company is willing to grant a leave of absence to an employee for this purpose for six months or longer, such an employee will be in a position to spot German technical information which might be of special interest to his own company.

DIVISION OF ENGINEERING AND INDUSTRIAL RESEARCH OF THE NATIONAL RESEARCH COUNCIL APPOINTS LOUIS JORDAN EXECUTIVE SECRETARY

Dean Frederick M. Feiker, Chairman, Division of Engineering and Industrial Research of the National Research Council, announces the appointment of Louis Jordan as Executive Secretary of the Division. Mr. Jordan has recently been Executive Secretary of the War Metallurgy Committee and Head Technical Aide, War Metallurgy Division of NDRC.

Mr. Jordan, trained initially as a chemist and metallurgist, was for many years a member of the staff of the metallurgical division of the National Bureau of Standards, directing research in chemical metallurgy, and in heat treatment and elevated temperature service of metals. He later served as Assistant Secretary of the American Institute of Mining and Metallurgical Engineers and as Executive Secretary of the Metals Divisions of the A.I.M.E. He returned to Washington in early 1941 and was on the staff of the Office of Production Management, later War Production Board, as a mineral commodity expert concerned with the production and allocation of nickel. In January 1942 he came to the National Research Council and was responsible throughout World War II for the administrative organization and operation of the War Metallurgy Committee in all of its activities as an advisory committee to OSRD and WPB in the fields of minerals and metals research and development.

SHEFFER PROMOTED

John W. Sheffer, General Electrical Engineer, American Car and Foundry Co., has been appointed General Improvement Engineer for ACF. In this capacity he will have direct charge of the Improvement Division with headquarters in New York. He has been with the company since 1908.

Mr. Sheffer graduated from Cornell University in 1907 with an M.E. degree and later in 1933 obtained his M.A. degree from Columbia University.

He began his association with ACF in 1908 at the Berwick plant as electrical engineer and later served in the capacities of assistant to the general superintendent and plant engineer. During these 17 years he was engaged also with welding developments of all description, and was in part responsible for important advances made in welding at ACF plants.

John W. Sheffer

In 1926 Mr. Sheffer transferred to the New York office and since that time has been occupied with improvement and development problems in the company's plants. Under his supervision major welding installations have been made at several ACF plants.

Mr. Sheffer holds memberships in the American Institute of Electrical Engineers, AMERICAN WELDING SOCIETY, and Iron and Steel Engineers.